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DNPS Offsite Dose Calculation Manual

OFFSITE DOSE CALCULATION MANUAL

DRESDEN STATION

UNITS 1, 2, 3

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OFFSITE DOSE CALCULATION MANUAL

Part I, RADIOACTIVE EFFLUENT CONTROLS

DRESDEN STATION

UNITS 1, 2, 3

1.0 USE AND APPLICATION

1.1 Definitions

-----NOTE-----

The defined terms of this section appear in capitalized type and are applicable throughout these Offsite Dose Calculation Manual (ODCM) Controls and Bases.

| <u>Term</u> | <u>Definition</u> |
|-------------------------|--|
| ACTION | ACTIONS shall be that part of a Control that prescribes Required Actions to be taken under designated Conditions within specified Completion Times. |
| CHANNEL CALIBRATION | A CHANNEL CALIBRATION shall be the adjustment, as necessary, of the channel output such that it responds within the necessary range and accuracy to known values of the parameter that the channel monitors. The CHANNEL CALIBRATION shall encompass the entire channel, including the sensors and alarm, display and interlock and/or trip functions, and shall include the CHANNEL FUNCTIONAL TEST. Calibration of instrument channels with resistance temperature detector (RTD) or thermocouple sensors may consist of an in-place qualitative assessment of sensor behavior and normal calibration of the remaining adjustable devices in the channel. The CHANNEL CALIBRATION may be performed by means of any series of sequential, overlapping, or total channel steps so that the entire channel is calibrated. |
| CHANNEL CHECK | A CHANNEL CHECK shall be the qualitative assessment, by observation, of channel behavior during operation. This determination shall include, where possible, comparison of the channel indication and/or status with other indications and/or status derived from independent instrument channels measuring the same parameter. |
| CHANNEL FUNCTIONAL TEST | A CHANNEL FUNCTIONAL TEST shall be the injection of a simulated or actual signal into the channel as close to the sensor as practicable to verify FUNCTIONALITY, including alarm and/or trip functions and channel failure trips. The CHANNEL FUNCTIONAL TEST may be performed by means of any series of sequential, overlapping, or total channel steps so that the entire channel is tested. |
| CONTINUOUS SAMPLING | Uninterrupted sampling with the exception of interruptions of short duration (no longer than 2 hours) for required surveillances or repair. |
| DOSE EQUIVALENT I-131 | DOSE EQUIVALENT I-131 shall be as defined in the Units 2/3 Technical Specifications. |

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(continued)

1.1 Definitions (continued)

| | | |
|--|--|-------------|
| FUNCTIONAL - FUNCTIONALITY | Functionality is an attribute of structures, systems, or components (SSCs) that is not controlled by Technical Specifications (TSs). An SSC is FUNCTIONAL or has FUNCTIONALITY when it is capable of performing its specified safety function, as set forth in the Current Licensing Basis. FUNCTIONALITY does not apply to specified safety functions, but does apply to the ability of non-TS SSCs to perform other specified functions that have a necessary support function. | May 2009 |
| GASEOUS RADWASTE TREATMENT SYSTEM | Any system designed and installed to reduce radioactive gaseous effluents by collecting primary coolant system offgases from the main condenser evacuation system and providing for delay or holdup for the purpose of reducing the total radioactivity prior to release to the environment. | |
| MEMBER OF THE PUBLIC | Any individual, except when that individual is receiving an OCCUPATIONAL DOSE. | |
| MODE | A MODE shall correspond to any one inclusive combination of mode switch position, average reactor coolant temperature, and reactor vessel head closure bolt tensioning specified in Technical Specifications with fuel in the reactor vessel. | |
| OCCUPATIONAL DOSE | The dose received by an individual in the course of employment in which the individual's assigned duties involve exposure to radiation and/or to radioactive material from licensed and unlicensed sources of radiation, whether in the possession of the licensee or other person. Occupational dose does not include dose from background radiation, as a patient from medical practices, from voluntary participation in medical research programs, or as a member of the public. | |
| OFFSITE DOSE CALCULATION MANUAL (ODCM) | The ODCM shall contain the methodology and parameters used in the calculation of offsite doses resulting from radioactive gaseous and liquid effluents, in the calculation of gaseous and liquid effluent monitoring Alarm/Trip Setpoints, and in the conduct of the Environmental Radiological Monitoring Program. The ODCM shall also contain (1) the Radioactive Effluent Controls and Radiological Environmental Monitoring Programs and (2) descriptions of the information that should be included in the Annual Radiological Environmental Operating and Radioactive Effluent Release Reports. The ODCM is document number CY-DR-170-301. | |
| PROCESS CONTROL PROGRAM (PCP) | The PCP shall contain the current formulas, sampling, analyses, test, and determinations to be made to ensure that processing and packaging of solid radioactive wastes based on demonstrated processing of actual or simulated wet solid wastes will be accomplished in such a way as to assure compliance with 10 CFR Parts 20, 61, and 71, Federal and State regulations, burial ground requirements, and other requirements governing the disposal of solid radioactive waste. | May 2009 |

(continued)

1.1 Definitions (continued)

| | |
|---------------------------------------|---|
| PUBLIC DOSE | PUBLIC DOSE means the dose received by a member of the public from exposure to radiation or radioactive material released by a licensee, or to any other source of radiation under the control of a licensee. Public dose does not include occupational dose or doses received from background radiation, from any medical administration the individual has received, from exposure to individuals administered radioactive material and released in accordance with 10CFR35.75, or from voluntary participation in medical research programs. |
| PURGE - PURGING | PURGE or PURGING shall be any controlled process of discharging air or gas from a confinement to maintain temperature, pressure, humidity, concentration or other operating condition, in such a manner that replacement air or gas is required to purify the confinement. |
| RADIOLOGICAL EFFLUENT CONTROLS (RECs) | A compilation of the various regulatory requirements, surveillance and bases, commitments and/or components of the radiological effluent and environmental monitoring programs for Dresden Station. |
| RATED THERMAL POWER (RTP) | RTP shall be a total reactor core heat transfer rate to the reactor coolant of 2957 MWt. |
| REACTOR POWER OPERATION | REACTOR POWER OPERATION is any operation with the mode switch in the "Startup/Hot Standby" or "Run" position with the reactor critical and above 1% rated thermal power. |
| REPORTABLE EVENT | A REPORTABLE EVENT shall be any of those conditions specified in 10CFR50.73. |
| RESTRICTED AREA | The RESTRICTED AREA is the area defined in ODCM Part II Figure 1-3 to which access is controlled by the licensee for purposes of protection of individuals from exposure to radiation and radioactive materials, and does not include any area within the SITE BOUNDARY used for residential quarters or for industrial, commercial, institutional, and/or recreational purposes. |
| SITE BOUNDARY | The SITE BOUNDARY shall be that line beyond which the land is not owned, leased, or otherwise controlled by licensee as defined in ODCM Part II Figure 1-2. |
| SOURCE CHECK | A SOURCE CHECK shall be the qualitative assessment of channel response when the channel sensor is exposed to a source of increased radioactivity. |

(continued)

1.1 Definitions (continued)

UNRESTRICTED AREA An UNRESTRICTED AREA shall be any area at or beyond the SITE BOUNDARY, access to which is not controlled by the licensee for purposes of protection of individuals from exposure to radiation and radioactive materials, or any area within the SITE BOUNDARY used for residential quarters or for industrial, commercial, institutional, and/or recreational purposes. Defined in ODCM Part II Figure 1-3.

VENTILATION EXHAUST TREATMENT SYSTEM A VENTILATION EXHAUST TREATMENT SYSTEM shall be any system designed and installed to reduce the gaseous radioiodine or radioactive material in particulate form in effluents by passing ventilation or vent exhaust gases through charcoal adsorbers and/or HEPA filters for the purpose of removing iodines or particulates from the gaseous exhaust stream prior to the release to the environment. Such a system is not considered to have any effect on noble gas effluents. Engineered Safety Features Atmospheric Cleanup Systems are not considered to be VENTILATION EXHAUST TREATMENT SYSTEM components.

VENTING VENTING shall be the controlled process of discharging air or gas from a confinement to maintain temperature, pressure, humidity, concentration, or other operating condition, in such a manner that replacement air or gas is not provided or required during VENTING. Vent, used in system names, does not imply a VENTING process.

DEFINITIONS RELATED TO ESTIMATING DOSE TO THE PUBLIC USING THE ODCM COMPUTER PROGRAM:

ACTUAL Refers to using known release data to project the dose to the public for the previous month. These data are stored in the database and used to demonstrate compliance with the reporting requirements of RECs.

PROJECTED Refers to using known release data from the previous month or estimated release data to forecast a future dose to the public. These data are NOT permanently incorporated into the database.

Table 1.1-1
Compliance Matrix

| Regulation | Dose / Component / Limit | ODCM Equation | RECS | Technical Specification | |
|--|---|--------------------|--------------------------------|--------------------------------|-------------|
| 10 CFR 50 Appendix I | 1. Gamma air dose and beta air dose due to airborne radioactivity in effluent plume. | 4-7 4-8 | 12.4.2 | (1) 6.8.D.4.h (2/3) 5.5.4.h | August 2009 |
| | 2. Whole body and skin dose due to airborne radioactivity in effluent plume are reported only if certain gamma and beta air dose criteria are exceeded: | 4-12 4-13 | N/A | N/A | |
| | a. Projected doses due to gaseous release, when averaged over 31 days, exceed 0.3 mrem to any organ. | N/A | 12.4.5 | (1) 6.8.D.4.f (2/3) 5.5.4.f | August 2009 |
| | b. Projected doses due to liquid release, when averaged over 31 days, exceed 0.06 mrem to the total body or 0.2 mrem to any organ. | N/A | 12.3.3 | (1) 6.8.D.4.f (2/3) 5.5.4.f | August 2009 |
| | 3. CDE for all organs and all four age groups due to iodines and particulates in effluent plume. All pathways are considered. | 4-14 | 12.4.3 | (1) 6.8.D.4.i (2/3) 5.5.4.i | August 2009 |
| 4. CDE for all organs and all four age groups due to radioactivity in liquid effluents. | 3-3 | 12.3.2 | (1) 6.8.D.4.d (2/3) 5.5.4.d | August 2009 | |
| 5. Implement environmental monitoring program, including, Land Use Census, Interlaboratory Comparison Program, and Annual Radiological Environmental Operating Report: | NA | 12.6 12.9.3 | (1) 6.9.A.3 (2/3) 5.6.2 | August 2009 | |
| 10CFR20 | 1. TEDE, totaling all deep dose equivalent components (direct, ground and plume shine) and CDE (all pathways, both airborne and liquid-borne). CDE evaluation is made for adult only using FGR 11 database. | 5-5 | 12.5.2 | (1) 6.8.D.4.d (2/3) 5.5.4.c | August 2009 |
| 40CFR190 (now by reference, also part of 10 CFR 20) | 1. Whole body dose (DDE) due to direct dose, ground, and plume shine from all sources at a station. | 5-2 | 12.5.1 | (1) 6.8.D.4.j (2/3) 5.5.4.j | August 2009 |
| | 2. Organ doses (CDE) to an adult due to all pathways. | 5-3 | | | |
| Technical Specifications | 1. Functional capability of effluent monitoring instrumentation. | NA | 12.2 | (1) 6.8.D.4.a (2/3) 5.5.4.a | August 2009 |
| | 2. "Instantaneous" concentration limits for liquid effluents. | 2-1 | 12.3.1 | (1) 6.8.D.4.b (2/3) 5.5.4.b | August 2009 |
| | 3. Determination of cumulative and projected doses from site effluents. | NA | 12.3.2 12.4.2 | (1) 6.8.D.4.e (2/3) 5.5.4.e | August 2009 |
| | 4. "Instantaneous" whole body (DDE), thyroid (CDE), and skin (SDE) dose rates to an adult due to radioactivity in airborne effluents. For the thyroid dose, only inhalation is considered. | 2-3 4-18 2-4 | 12.4.1 | (1) 6.8.D.4.g (2/3) 5.5.4.g | August 2009 |
| | 5. Radioactive Effluent Release Report | N/A | 12.9.4 | (1) 6.9.A.4 (2/3) 5.6.3 | August 2009 |

1.0 USE AND APPLICATION

1.2 Logical Connectors

PURPOSE The purpose of this section is to explain the meaning of logical connectors.

Logical connectors are used in ODCM to discriminate between, and yet connect, discrete Conditions, Required Actions, Completion Times, Surveillances, and Frequencies. The only logical connectors that appear in ODCM are AND and OR. The physical arrangement of these connectors constitutes logical conventions with specific meanings.

BACKGROUND Several levels of logic may be used to state Required Actions. These levels are identified by the placement (or nesting) of the logical connectors and by the number assigned to each Required Action. The first level of logic is identified by the first digit of the number assigned to a Required Action and the placement of the logical connector in the first level of nesting (i.e., left justified with the number of the Required Action). The successive levels of logic are identified by additional digits of the Required Action number and by successive indentations of the logical connectors.

When logical connectors are used to state a Condition, Completion Time, Surveillance, or Frequency, only the first level of logic is used, and the logical connector is left justified with the statement of the Condition, Completion Time, Surveillance, or Frequency.

EXAMPLES The following examples illustrate the use of logical connectors.

(continued)

1.2 Logical Connectors

EXAMPLES
(continued)

EXAMPLE 1.2-1

ACTIONS

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|---------------------|---|-----------------|
| A. Control not met. | A.1 Verify . . . <u>AND</u> A.2 Restore . . . | |

In this example, the logical connector AND is used to indicate that, when in Condition A, both Required Actions A.1 and A.2 must be completed.

(continued)

1.2 Logical Connectors

EXAMPLES
(continued)

EXAMPLE 1.2-2

ACTIONS

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|---------------------|---|-----------------|
| A. Control not met. | A.1 Trip ... <u>OR</u> A.2.1 Verify ... <u>AND</u> A.2.2.1 Reduce ... <u>OR</u> A.2.2.2 Perform ... <u>OR</u> A.3 Align | |

This example represents a more complicated use of logical connectors. Required Actions A.1, A.2 and A.3 are alternate choices, only one of which must be performed as indicated by the use of the logical connector OR and the left justified placement. Any one of these three ACTIONS may be chosen. If A.2 is chosen, then both A.2.1 and A.2.2 must be performed as indicated by the logical connector AND. Required Action A.2.2 is met by performing A.2.2.1 or A.2.2.2. The indented position of the logical connector OR indicates that A.2.2.1 and A.2.2.2 are alternative choices, only one of which must be performed.

1.0 USE AND APPLICATION

1.3 Completion Times

PURPOSE The purpose of this section is to establish the Completion Time convention and to provide guidance for its use.

BACKGROUND ODCM Radiological Effluent Controls (RECs) specify minimum requirements for ensuring safe operation of the unit as allowed by Technical Specifications (TS) 6.8.D.4 (Unit 1) and 5.5.4 (Units 2 and 3). The ACTIONS associated with a REC state Conditions that typically describe the ways in which the requirements of the REC can fail to be met. Specified with each stated Condition are Required Action(s) and Completion Time(s).

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DESCRIPTION The Completion Time is the amount of time allowed for completing a Required Action. It is referenced to the time of discovery of a situation (e.g., non-functional equipment or variable not within limits) that requires entering an ACTIONS Condition unless otherwise specified, providing the unit is in a MODE or specified condition stated in the Applicability of the REC. Required Actions must be completed prior to the expiration of the specified Completion Time. An ACTIONS Condition remains in effect and the Required Actions apply until the Condition no longer exists or the unit is not within the REC Applicability.

If situations are discovered that require entry into more than one Condition at a time within a single REC (multiple Conditions), the Required Actions for each Condition must be performed within the associated Completion Time. When in multiple Conditions, separate Completion Times are tracked for each Condition starting from the time of discovery of the situation that required entry into the Condition.

Once a Condition has been entered, subsequent divisions, subsystem, components or variables expressed in the Condition, discovered to be non-functional or not within limits, will not result in separate entry into the Condition unless specifically stated. The Required Actions of the Condition continue to apply to each additional failure, with Completion Times based on initial entry into the Condition.

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(continued)

1.3 Completion Times

DESCRIPTION
(continued)

However, when a subsequent division, subsystem, component, or variable expressed in the Condition is discovered to be non-functional or not within limits, the Completion Time(s) may be extended. To apply this Completion Time extension, two criteria must first be met. The subsequent loss of FUNCTIONALITY:

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- a. Must exist concurrent with the first loss of FUNCTIONALITY; and
- b. Must remain non-functional or not within limits after the first loss of FUNCTIONALITY is resolved.

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The total Completion Time allowed for completing a Required Action to address the subsequent loss of FUNCTIONALITY shall be limited to the more restrictive of either:

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- a. The stated Completion Time, as measured from the initial entry into the Condition, plus an additional 24 hours; or
- b. The stated Completion Time as measured from discovery of the subsequent loss of FUNCTIONALITY.

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The above Completion Time extension does not apply to those RECs that have exceptions that allow completely separate re-entry into the Condition (for each division, subsystem, component, or variable expressed in the Condition) and separate tracking of Completion Times based on this re-entry. These exceptions are stated in individual RECs.

The above Completion Time extension does not apply to a Completion Time with a modified "time zero." This modified "time zero" may be expressed as a repetitive time (i.e., "once per 8 hours," where the Completion Time is referenced from a previous completion of the Required Action versus the time of Condition entry) or as a time modified by the phrase "from discovery..." Example 1.3-3 illustrates one use of this type of Completion Time. The 10 day Completion Time specified for Condition A and B in Example 1.3-3 may not be extended.

EXAMPLES

The following examples illustrate the use of Completion Times with different types of Conditions and changing Conditions.

(continued)

1.3 Completion Times

EXAMPLES
(continued)

EXAMPLE 1.3-1

ACTIONS

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|--|---------------------------------|-----------------|
| B. Required Action and associated Completion Time not met. | B.1 Be in MODE 3. | 12 hours |
| | <u>AND</u> B.2 Be in MODE 4. | 36 hours |

Condition B has two Required Actions. Each Required Action has its own separate Completion Time. Each Completion Time is referenced to the time that Condition B is entered.

The Required Actions of Condition B are in to be in MODE 3 within 12 hours AND in MODE 4 within 36 hours. A total of 12 hours is allowed for reaching MODE 3 and a total of 36 hours (not 48 hours) is allowed for reaching MODE 4 from the time that Condition B was entered. If MODE 3 is reached within 6 hours, the time allowed for reaching MODE 4 is the next 30 hours because the total time allowed for reaching Mode 4 is 36 hours.

If Condition B is entered while in MODE 3, the time allowed for reaching MODE 4 is the next 36 hours.

(continued)

1.3 Completion Times

EXAMPLES
(continued)

EXAMPLE 1.3-2

ACTIONS

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|--|---|-----------------|
| A. One monitor non-functional. | A.1 Restore monitor to FUNCTIONAL status. | 7 days |
| B. Required Action and associated Completion Time not met. | B.1 Be in MODE 3. | 12 hours |
| | <u>AND</u> B.2 Be in MODE 4. | 36 hours |

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When a monitor is declared non-functional, Condition A is entered. If the monitor is not restored to FUNCTIONAL status within 7 days, Condition B is also entered and the Completion Time clocks for Required Action B.1 and B.2 start. If the non-functional monitor is restored to FUNCTIONAL status after Condition B is entered, Condition A and B are exited, and therefore, the Required Actions of Condition B may be terminated.

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When a second monitor is declared non-functional while the first monitor is still non-functional, Condition A is not re-entered for the second monitor. REC 12.0.3 is entered, since the ACTIONS do not include a Condition for more than one non-functional monitor. The Completion Time clock for Condition A does not stop after REC 12.0.3 is entered, but continues to be tracked from the time Condition A was initially entered.

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While in REC 12.0.3, if one of the non-functional monitors is restored to FUNCTIONAL status and the Completion Time for Condition A has not expired, REC 12.0.3 may be exited and operation continued in accordance with Condition A.

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(continued)

1.3 Completion Times

EXAMPLES
(continued)

EXAMPLE 1.3-2 (continued)

While in REC 12.0.3, if one of the non-functional monitors is restored to FUNCTIONAL status and the Completion Time for Condition A has expired, REC 12.0.3 may be exited and operation continued in accordance with Condition B. The Completion Time for Condition B is tracked from the time the Condition A Completion Time expired.

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On restoring one of the monitors to FUNCTIONAL status, the Condition A Completion Time is not reset, but continues from the time the first monitor was declared non-functional. This Completion Time may be extended if the monitor restored to FUNCTIONAL status was the first non-functional monitor. A 24 hour extension to the stated 7 days is allowed, provided this does not result in the second monitor being non-functional for > 7 days.

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(continued)

1.3 Completion Times

EXAMPLES
(continued)

EXAMPLE 1.3-3

ACTIONS

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|--|--|--|
| <p>A. One Function X subsystem non-functional.</p> | <p>A.1 Restore Function X subsystem to FUNCTIONAL status.</p> | <p>7 days</p> <p><u>AND</u></p> <p>10 days from discovery of failure to meet the Control</p> |
| <p>B. One Function Y subsystem non-functional.</p> | <p>B.1 Restore Function Y subsystem to FUNCTIONAL status.</p> | <p>72 hours</p> <p><u>AND</u></p> <p>10 days from discovery to meet Control</p> |
| <p>C. One Function X subsystem non-functional.</p> <p><u>AND</u></p> <p>One Function Y subsystem non-functional.</p> | <p>C.1 Restore Function X subsystem to FUNCTIONAL status.</p> <p><u>OR</u></p> <p>C.2 Restore Function Y subsystem to FUNCTIONAL status.</p> | <p>72 hours</p> <p>72 hours</p> |

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(continued)

1.3 Completion Times

EXAMPLES
(continued)

EXAMPLE 1.3-3 (continued)

When one Function X subsystem and one Function Y subsystem are non-functional, Condition A and Condition B are concurrently applicable. The Completion Times for Condition A and Condition B are tracked separately for each subsystem, starting from the time each subsystem was declared non-functional and the Condition was entered. A separate Completion Time is established for Condition C and tracked from the time the second subsystem was declared non-functional (i.e., the time the situation described in Condition C was discovered).

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If Required Action C.2 is completed within the specified Completion Time, Conditions B and C are exited. If the Completion Time for Required Action A.1 has not expired, operation may continue in accordance with Condition A. The remaining Completion Time in Condition A is measured from the time the affected subsystem was declared non-functional (i.e., initial entry into Condition A).

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The Completion Times of Conditions A and B are modified by a logical connector, with a separate 10 day Completion Time measured from the time it was discovered the REC was not met. In this example, without the separate Completion Time, it would be possible to alternate between Conditions A, B, and C in such a manner that operation could continue indefinitely without ever restoring systems to meet the REC. The separate Completion Time modified by the phrase "from discovery of failure to meet the Control" is designed to prevent indefinite continued operation while not meeting the REC. This Completion Time allows for an exception to the normal "time zero" for beginning the Completion Time "clock." In this instance, the Completion Time "time zero" is specified as commencing at the time the REC was initially not met, instead of at the time the associated Condition was entered.

(continued)

1.3 Completion Times

EXAMPLES
(continued)

EXAMPLE 1.3-4

ACTIONS

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|--|--|-----------------|
| A. One or more instruments non-functional. | A.1 Restore instrument(s) to FUNCTIONAL status. | 4 hours |
| B. Required Action and associated Completion Time not met. | B.1 Be in MODE 3. | 12 hours |
| | <u>AND</u> B.2 Be in MODE 4. | 36 hours |

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A single Completion Time is used for any number of instruments non-functional at the same time. The Completion Time associated with Condition A is based on the initial entry into Condition A and is not tracked on a per instrument basis. Declaring subsequent instruments non-functional, while Condition A is still in effect, does not trigger the tracking of separate Completion Times.

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Once one of the instruments has been restored to FUNCTIONAL status, the Condition A Completion Time is not reset, but continues from the time the first instrument was declared non-functional. The Completion Time may be extended if the instrument restored to FUNCTIONAL status was the first non-functional instrument. The Condition A Completion Time may be extended for up to 4 hours provided this does not result in any subsequent instrument being non-functional for > 4 hours.

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If the Completion Time of 4 hours (plus the extension) expires while one or more instruments are still non-functional, Condition B is entered.

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(continued)

1.3 Completion Times

EXAMPLES
(continued)

EXAMPLE 1.3-5

ACTIONS

-----NOTE-----

Separate Condition entry is allowed for each non-functional instrument.

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| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|--|---|-----------------|
| A. One or more instruments non-functional. | A.1 Restore instrument(s) to FUNCTIONAL status. | 4 hours |
| B. Required Action and associated Completion Time not met. | B.1 Be in MODE 3. | 12 hours |
| | <u>AND</u> B.2 Be in MODE 4. | 36 hours |

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The Note above the ACTIONS Table is a method of modifying how the Completion Time is tracked. If this method of modifying how the Completion Time is tracked was applicable only to a specific Condition, the Note would appear in that Condition rather than at the top of the ACTIONS Table.

The Note allows Condition A to be entered separately for each non-functional instrument, and Completion Times tracked on a per instrument basis. When an instrument is declared non-functional, Condition A is entered and its Completion Time starts. If subsequent instruments are declared non-functional, Condition A is entered for each instrument and separate Completion Times start and are tracked for each instrument.

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If the Completion Time associated with an instrument in Condition A expires, Condition B is entered for that instrument. If the Completion Times associated with subsequent instruments in Condition A expire, Condition B is entered separately for each instrument and separate Completion Times start and are tracked for each instrument. If an instrument that caused entry into Condition B is restored to FUNCTIONAL status, Condition B is exited for that instrument.

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Since the Note in this example allows multiple Condition entry and tracking of separate Completion Times, Completion Time extensions do not apply.

(continued)

1.3 Completion Times

EXAMPLES
(continued)

EXAMPLE 1.3-6

ACTIONS

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|--|---|------------------|
| A. One channel non-functional. | A.1 Perform RSR 12.x.x.x. | Once per 8 hours |
| | <u>OR</u> A.2 Reduce THERMAL POWER to ≤ 50% RTP. | 8 hours |
| B. Required Action and associated Completion Time not met. | B.1 Be in MODE 3. | 12 hours |

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Entry into Condition A offers a choice between Required Action A.1 and A.2. Required Action A.1 has a "once per" Completion Time, which qualifies for the 25% extension, per RSR 12.0.2 to each performance after the initial performance. The initial 8 hour interval of Required Action A.1 begins when Condition A is entered and the initial performance of Required Action A.1 must be completed within the first 8 hour interval. If Required Action A.1 is followed and the Required Action is not met within the Completion Time (plus the extension allowed by RSR 12.0.2), Condition B is entered. If Required Action A.2 is followed and the Completion Time of 8 hours is not met, Condition B is entered.

If after entry into Condition B, Required Action A.1 or A.2 is met, Condition B is exited and operation may then continue in Condition A.

(continued)

1.3 Completion Times

EXAMPLES
(continued)

EXAMPLE 1.3-7

ACTIONS

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|--|---|---|
| A. One subsystem non-functional. | A.1 Verify affected subsystem isolated. | 1 hour <u>AND</u> Once per 8 hours thereafter |
| | <u>AND</u> A.2 Restore subsystem to FUNCTIONAL status. | 72 hours |
| B. Required Action and associated Completion Time not met. | B.1 Be in MODE 3. | 12 hours |
| | <u>AND</u> B.2 Be in MODE 4. | 36 hours |

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Required Action A.1 has two Completion Times. The 1 hour Completion Time begins at the time the Condition is entered and each "Once per 8 hours thereafter" interval begins upon performance of Required Action A.1.

If after Condition A is entered, Required Action A.1 is not met within either the initial 1 hour or any subsequent 8 hour interval from the previous performance (plus the extension allowed by RSR 12.0.2), Condition B is entered. The Completion Time clock for Condition A does not stop after Condition B is entered, but continues from the time Condition A was initially entered. If Required Action A.1 is met after Condition B is entered, Condition B is exited and operation may continue in accordance with Condition A, provided the Completion Time for Required Action A.2 has not expired.

IMMEDIATE
COMPLETION
TIME

When "Immediately" is used as a Completion Time, the Required Action should be pursued without delay and in a controlled manner.

1.0 USE AND APPLICATION

1.4 Frequency

PURPOSE The purpose of this section is to define the proper use and application of Frequency requirements.

DESCRIPTION Each ODCM Radiological Effluent Surveillance Requirement (RSR) has a specified Frequency in which the Surveillance must be met in order to meet the associated ODCM REC. An understanding of the correct application of the specified Frequency is necessary for compliance with the RSR.

The "specified Frequency" is referred to throughout this section and each of the Requirements of Section 12.0, ODCM Radiological Effluent Surveillance Requirement (RSR) Applicability. The "specified Frequency" consists of the requirements of the Frequency column of each RSR, as well as certain Notes in the Surveillance column that modify performance requirements.

Sometimes special situations dictate when the requirements of a Surveillance are to be met. They are "otherwise stated" conditions allowed by RSR 12.0.1. They may be stated as clarifying Notes in the Surveillance, as part of the Surveillance, or both. Example 1.4-4 discusses these special situations.

Situations where a Surveillance could be required (i.e., its Frequency could expire), but where it is not possible or not desired that it be performed until sometime after the associated REC is within its Applicability, represent potential RSR 12.0.4 conflicts. To avoid these conflicts, the RSR (i.e., the Surveillance or the Frequency) is stated such that it is only "required" when it can be and should be performed. With a RSR satisfied, RSR 12.0.4 imposes no restriction.

The use of "met" or "performed" in these instances conveys specified meanings. A Surveillance is "met" only when the acceptance criteria are satisfied. Known failure of the requirements of a Surveillance, even without a Surveillance specifically being "performed," constitutes a Surveillance not "met."

"Performance" refers only to the requirement to specifically determine the ability to meet the acceptance criteria. RSR 12.0.4 restrictions would not apply if both the following conditions are satisfied:

- a. The Surveillance is not required to be performed; and
- b. The Surveillance is not required to be met or, even if required to be met, is not known to be failed.

(continued)

1.0 USE AND APPLICATION

1.4 Frequency

EXAMPLES

The following examples illustrate the various ways that Frequencies are specified. In these examples, the Applicability of the REC (REC not shown) is MODES 1, 2, and 3.

EXAMPLE 1.4-1

SURVEILLANCE REQUIREMENTS

| SURVEILLANCE | FREQUENCY |
|-----------------------|-----------|
| Perform CHANNEL CHECK | 12 hours |

Example 1.4-1 contains the type of RSR most often encountered in the ODCM. The Frequency specifies an interval (12 hours) during which the associated Surveillance must be performed at least one time. Performance of the Surveillance initiates the subsequent interval. Although the Frequency is stated as 12 hours, an extension of the time interval to 1.25 times the interval specified in the Frequency is allowed by RSR 12.0.2 for operational flexibility. The measurement of this interval continues at all times, event when the RSR is not required to be met per RSR 12.0.1 (such as when the equipment is non-functional, a variable is outside specified limits, or the unit is outside the Applicability of the REC). If the interval specified by RSR 12.0.2 is exceeded while the unit is in a MODE or other specified condition in the Applicability of the REC, and the performance of the Surveillance is not otherwise modified (refer to Examples 1.4-3 and 1.4-4), then RSR 12.0.3 becomes applicable.

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If the interval as specified by RSR 12.0.2 is exceeded while the unit is not in a MODE or other specified condition in the Applicability of the REC for which performance of the RSR is required, the Surveillance must be performed within the Frequency requirements of RSR 12.0.2 prior to entry into the MODE or other specified condition. Failure to do so would result in a violation of RSR 12.0.4.

(continued)

1.0 USE AND APPLICATION

1.4 Frequency

EXAMPLES

EXAMPLE 1.4-2

SURVEILLANCE REQUIREMENTS

| SURVEILLANCE | FREQUENCY |
|-------------------------------|---|
| Verify flow is within limits. | Once within 12 hours after $\geq 25\%$ RTP <u>AND</u> 24 hours thereafter |

Example 1.4-2 has two Frequencies. The first is a one time performance Frequency, and the second is of the type shown in Example 1.4-1. The logical connector "AND" indicates that both Frequency requirements must be met. Each time reactor power is increased from a power level $< 25\%$ RTP to $\geq 25\%$ RTP, the Surveillance must be performed within 12 hours.

The use of "once" indicates a single performance will satisfy the specified Frequency (assuming no other Frequencies are connected by "AND"). This type of Frequency does not qualify for the extension allowed by RSR 12.0.2.

"Thereafter" indicates future performances must be established per RSR 12.0.2, but only after a specified condition is first met (i.e., the "once" performance in this example). If reactor power decreases to $< 25\%$ RTP, the measurement of both intervals stops. New intervals start upon reactor power reaching 25% RTP.

(continued)

1.0 USE AND APPLICATION

1.4 Frequency

EXAMPLES

EXAMPLE 1.4-3

| SURVEILLANCE REQUIREMENTS | |
|---|-----------|
| SURVEILLANCE | FREQUENCY |
| <p>-----NOTE----- Not required to be performed until 12 hours after $\geq 25\%$ RTP. -----</p> | |
| Perform channel adjustment. | 7 days |

The interval continues whether or not the unit operation is $< 25\%$ RTP between performances.

As the Note modifies the required performance of the Surveillance, it is construed to be part of the "specified Frequency." Should the 7 day interval be exceeded while operation is $< 25\%$ RTP, this Note allows 12 hours after power reaches $\geq 25\%$ RTP to perform the Surveillance. The Surveillance is still considered to be within the "specified Frequency." Therefore, if the Surveillance were not performed within the 7 day interval (plus the extension allowed by RSR 12.0.2), but operation was $< 25\%$ RTP, it would not constitute a failure of the RSR or failure to meet the REC. Also, no violation of RSR 12.0.4 occurs when changing MODES, even with the 7 day Frequency not met, provided operation does not exceed 12 hours with power $\geq 25\%$ RTP.

Once the unit reaches 25% RTP, 12 hours would be allowed for completing the Surveillance. If the Surveillance were not performed within this 12-hour interval, there would then be a failure to perform a Surveillance within the specified Frequency, and the provisions of RSR 12.0.3 would apply.

(continued)

1.0 USE AND APPLICATION

1.4 Frequency

EXAMPLES

EXAMPLE 1.4-4

SURVEILLANCE REQUIREMENTS

| SURVEILLANCE | FREQUENCY |
|--|-----------------|
| <p>-----NOTE----- Only required to be met in MODE 1. -----</p> | |
| <p>Verify leakage rates are within limits.</p> | <p>24 hours</p> |

Example 1.4-4 specifies that the requirements of this Surveillance do not have to be met until the unit is in MODE 1. The interval measurement for the Frequency of this Surveillance continues at all times, as described in Example 1.4-1. However, the Note constitutes an "otherwise stated" exception to the Applicability of this Surveillance. Therefore, if the Surveillance were not performed within the 24 hour interval (plus the extension allowed by RSR 12.0.2), but the unit was not in MODE 1, there would be no failure of the RSR nor failure to meet the REC. Therefore, no violation of RSR 12.0.4 occurs when changing MODES, even with the 24 hour Frequency exceeded, provided the MODE change was not made into MODE 1. Prior to entering MODE 1 (assuming again that the 24 hour Frequency were not met), RSR 12.0.4 would require satisfying the RSR.

1.0 USE AND APPLICATION

1.5 REC and RSR Implementation

The requirements of the Technical Specifications shall take precedence over this ODCM, should any differences occur.

The ODCM provides those limitations upon plant operations which are part of the licensing basis for the station but do not meet the criteria for continued inclusion in the Technical Specifications.

It also provides information that supplements the Technical Specifications by implementing the following Technical Specification requirements:

- a. Unit 1
 - 1. 6.8.A.6, ODCM Implementation
 - 2. 6.8.D.4, Radioactive Effluent Controls Program
 - 3. 6.9.A.3, Annual Radiological Environmental Operating Report
 - 4. 6.9.A.4, Radioactive Effluent Release Report
 - 5. 6.14, ODCM
- b. Units 2 and 3
 - 1. 5.5.1, ODCM
 - 2. 5.5.4, Radioactive Effluent Controls Program
 - 3. 5.6.2, Annual Radiological Environmental Operating Report
 - 4. 5.6.3, Radioactive Effluent Release Report

RECs and RSRs are implemented the same as Technical Specifications (see 12.0 Applicability). However, RECs and RSRs are treated as plant procedures and are not part of the Technical Specifications. Therefore the following exceptions apply:

- a. Violations of the Action or Surveillance requirements in a REC are not reportable as conditions prohibited by, or deviations from, the Technical Specifications per 10 CFR 50.72 or 10 CFR 50.73.
 - b. Power reduction or plant shutdowns required to comply with the Actions of a REC are not reportable per 10 CFR 50.72 or 10 CFR 50.73.
-

2.0 through 11.0 NOT USED

INTENTIONALLY BLANK

Sections 2.0 through 11.0 are not used in the RECs in order to maintain the original ODCM numbering convention.

12 CONTROLS AND SURVEILLANCE REQUIREMENTS

12.0 RADIOLOGICAL EFFLUENT CONTROL (REC) APPLICABILITY

REC 12.0.1 RECs shall be met during the MODES or other specified conditions in the Applicability, except as provided in REC 12.0.2.

REC 12.0.2 Upon discovery of a failure to meet a REC, the Required Actions of the associated Conditions shall be met, except as provided in REC 12.0.5.

If the REC is met or is no longer applicable prior to expiration of the specified Completion Time(s), completion of the Required Action(s) is not required, unless otherwise stated.

REC 12.0.3 When a REC is not met and the associated ACTIONS are not met, an associated ACTION is not provided, or if directed by the associated ACTIONS, action shall be initiated within 1 hour to:

- a. Implement appropriate compensatory actions as needed;
- b. Verify that the plant is not in an unanalyzed condition or that a required safety function is not compromised by the loss of FUNCTIONALITY; and
- c. Within 12 hours, obtain Station Duty Officer approval of the compensatory actions and the plan for exiting REC 12.0.3.

Exceptions to this REC are stated in the individual RECs.

Where corrective measures are completed that permit operation in accordance with the REC or ACTIONS, completion of the actions required by REC 12.0.3 is not required.

REC 12.0.3 is only applicable in Modes 1, 2, and 3.

REC 12.0.4 When a REC is not met, entry into a MODE or other specified condition in the Applicability shall only be made:

- a. When the associated ACTIONS to be entered permit continued operation in the MODE or other specified condition in the Applicability for an unlimited period of time;
- b. After performance of a risk assessment addressing non-functional systems and components, consideration of the results, determination of the acceptability of entering the MODE or other specified condition in the Applicability, and establishment of risk management actions, if appropriate; exceptions to the REC are stated in the individual RECs, or
- c. When an allowance is stated in the individual value, parameter, or other REC.

This REC shall not prevent changes in MODES or other specified conditions in the Applicability that are required to comply with ACTIONS or that are part of a shutdown of the unit.

(continued)

12.0 REC APPLICABILITY

REC 12.0.5 Equipment removed from service or declared non-functional to comply with ACTIONS may be returned to service under administrative control solely to perform testing required to demonstrate its FUNCTIONALITY or the FUNCTIONALITY of other equipment. This is an exception to REC 12.0.2 for the system returned to service under administrative control to perform the testing required to demonstrate FUNCTIONALITY.

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REC 12.0.6 RECs, including associated ACTIONS, shall apply to each unit individually, unless otherwise indicated. Whenever the REC refers to a system or component that is shared by both units, the ACTIONS will apply to both units simultaneously.

12.0 RADIOLOGICAL EFFLUENT SURVEILLANCE REQUIREMENT (RSR) APPLICABILITY

RSR 12.0.1 Radiological Effluent Surveillance Requirements (RSRs) shall be met during the MODES or other specified conditions in the Applicability for individual RECs, unless otherwise stated in the RSR. Failure to meet a Surveillance, whether such failure is experienced during the performance of the Surveillance or between performances of the Surveillance, shall be failure to meet the REC. Failure to perform a Surveillance within the specified Frequency shall be failure to meet the REC except as provided in RSR 12.0.3. Surveillances do not have to be performed on non-functional equipment or variables outside specified limits.

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RSR 12.0.2 The specified Frequency for each RSR is met if the Surveillance is performed within 1.25 times the interval specified in the Frequency, as measured from the previous performance or as measured from the time a specified condition of the Frequency is met.

For Frequencies specified as "once," the above interval extension does not apply.

If a Completion Time requires periodic performance on a "once per..." basis, the above Frequency extension applies to each performance after the initial performance.

Exceptions to this RSR are stated in the individual RSRs.

RSR 12.0.3 If it is discovered that a Surveillance was not performed within its specified Frequency, then compliance with the requirement to declare the REC not met may be delayed, from the time of discovery, up to 24 hours or up to the limit of the specified Frequency, whichever is greater. This delay period is permitted to allow performance of the Surveillance. A risk evaluation shall be performed for any Surveillance delayed greater than 24 hours and the risk impact shall be managed.

If the RSR is not performed within the delay period, the REC must immediately be declared not met, and the applicable Condition(s) must be entered.

When the Surveillance is performed within the delay period and the Surveillance is not met, the REC must immediately be declared not met, and the applicable Condition(s) must be entered.

RSR 12.0.4 Entry into a MODE or other specified condition in the Applicability of a REC shall only be made when the REC's RSR have been met within their specified Frequency, except as provided by RSR 12.0.3. When a REC is not met due to RSRs not having been met, entry into a MODE or other specified condition in the Applicability shall only be made in accordance with REC 12.0.4.

This provision shall not prevent entry into MODES or other specified conditions in the Applicability that are required to comply with ACTIONS or that are part of a shutdown of the unit.

RSR 12.0.5 RSRs shall apply to each unit individually, unless otherwise indicated.

12.1 NOT USED

INTENTIONALLY BLANK

Section 12.1 is not used in the RECs in order to maintain the original ODCM numbering convention.

12.2 INSTRUMENTATION

12.2.1 RADIOACTIVE LIQUID EFFLUENT MONITORING INSTRUMENTATION

REC 12.2.1 The following conditions shall be met:

- a. The effluent monitoring instrumentation in Table 12.2-1 shall be FUNCTIONAL with their alarm setpoints set to ensure the limits of REC 12.3.1 are not exceeded; AND
- b. The effluent monitoring instrument alarm setpoints shall be determined and adjusted in accordance with the methodology and parameters in the ODCM.

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APPLICABILITY: When flow is present in the system.

ACTIONS

NOTES

- 1. Separate Condition entry is allowed for each instrument.
- 2. The provisions of REC 12.0.3 and REC 12.0.4 are not applicable.
- 3. All deviations are reported in the Radioactive Effluent Release Report.

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|--|---|-----------------|
| A. Number of instrument channels FUNCTIONAL less than required by Table 12.2-1. | A.1 Enter the Condition referenced in Table 12.2-1 for the instrument channel. | Immediately |
| B. Radioactive liquid effluent monitoring instrument channel alarm setpoint less conservative than required. | B.1 Suspend the release of radioactive liquid effluents monitored by the affected instrument channel. | Immediately |
| | <u>OR</u> | |
| | B.2 Declare the affected instrument channel non-functional. | Immediately |
| | <u>OR</u> | |
| | B.3 Change the affected instrument setpoint so it is acceptably conservative. | Immediately |

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(continued)

ACTIONS (continued)

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|--|---|---|
| <p>C. As required by Required Action A.1 and referenced in Table 12.2-1.</p> | <p>C.1.1 Analyze two independent samples of tank's contents for principle gamma emitters, dissolved and entrained gases, I-131, and H-3 at LLDs specified in Table 12.3-2.</p> <p><u>AND</u></p> | <p>Prior to release</p> |
| | <p>C.1.2 Perform independent verification of the release rate calculations and discharge line valve line-up using at least two technically qualified members of the facility staff.</p> <p><u>AND</u></p> | <p>Prior to release</p> |
| | <p>C.2 Return the instrument channel to FUNCTIONAL status.</p> | <p>30 days</p> |
| <p>D. As required by Required Action A.1 and referenced in Table 12.2-1.</p> | <p>D.1 Analyze affected effluent grab samples for principle gamma emitters and I-131 at LLDs specified in Table 12.3-2.</p> <p><u>AND</u></p> | <p>Once per 12 hours</p> |
| | <p>D.2 Return the instrument channel to FUNCTIONAL status.</p> | <p>30 days</p> |
| <p>E. Required Action C.2 or D.2 and associated Completion Time not met.</p> | <p>E.1 Explain why the loss of functionality was not corrected in a timely manner in the Radioactive Effluent Release Report.</p> | <p>In accordance with Units 2/3 TS 5.6.3.</p> |

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12.2.1 SURVEILLANCE REQUIREMENTS

-----NOTE-----

CHANNEL CHECK, CHANNEL FUNCTIONAL TEST, and CHANNEL CALIBRATION are not required when the instruments are NOT required to be FUNCTIONAL or are tripped.

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| SURVEILLANCE REQUIREMENT | | FREQUENCY |
|--------------------------|---|-----------|
| RSR 12.2.1.1 | Perform CHANNEL CHECK. | 24 hours |
| RSR 12.2.1.2 | Perform CHANNEL FUNCTIONAL TEST, which may be performed by using trip check and test circuitry associated with the monitor chassis. This test shall also demonstrate that control room annunciation occurs if any of the following conditions exist: <ol style="list-style-type: none"> 1. Instrument indicates measured levels above the Alarm setpoint, or 2. Circuit failure, or 3. Instrument indicates a downscale failure, or 4. Instrument controls not set in Operate mode. | 92 days |
| RSR 12.2.1.3 | Perform SOURCE CHECK, which may be performed by observing instrument response during a discharge. | 24 months |
| RSR 12.2.1.4 | Perform SOURCE CHECK. | 24 months |
| RSR 12.2.1.5 | Perform CHANNEL CALIBRATION, which shall include performance of a CHANNEL FUNCTIONAL CHECK and SOURCE CHECK. | 24 months |

Table 12.2-1
RADIOACTIVE LIQUID EFFLUENT MONITORING INSTRUMENTATION
UNITS 2 & 3

| INSTRUMENT | REQUIRED CHANNELS PER INSTRUMENT | CONDITION REFERENCED FROM REQUIRED ACTION A.1 | SURVEILLANCE REQUIREMENT |
|--|----------------------------------|---|--|
| 1. Radioactivity Monitors Providing Alarm But Not Providing Automatic Termination of Release | | | |
| a. Liquid Radwaste Effluent Gross Activity Monitor | 1 | C | RSR 12.2.1.1 RSR 12.2.1.2 RSR 12.2.1.3 RSR 12.2.1.5 |
| b. Service Water Effluent Gross Activity Monitor (Unit 2) | 1 | D | RSR 12.2.1.1 RSR 12.2.1.2 RSR 12.2.1.4 RSR 12.2.1.5 |
| c. Service Water Effluent Gross Activity Monitor (Unit 3) | 1 | D | RSR 12.2.1.1 RSR 12.2.1.2 RSR 12.2.1.4 RSR 12.2.1.5 |

12.2 INSTRUMENTATION

12.2.2 RADIOACTIVE GASEOUS EFFLUENT MONITORING INSTRUMENTATION

REC 12.2.2 The following conditions shall be met:

- a. The effluent monitoring instrumentation in Table 12.2-2 shall be FUNCTIONAL with alarm setpoints set to ensure the limits of REC 12.4.1, REC 12.4.2 and REC 12.4.3 are not exceeded;
- b. The effluent monitoring instrument alarm setpoints shall be determined in accordance with the methodology and parameters in the ODCM.

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APPLICABILITY: As shown in Table 12.2-2.

ACTIONS

NOTES

1. Separate Condition entry is allowed for each instrument channel.
2. The provisions of REC 12.0.3 and REC 12.0.4 are not applicable.
3. All deviations are reported in the Radioactive Effluent Release Report.
4. Channels may be removed from service for short durations without implementing REQUIRED ACTIONS as long as CONTINUOUS SAMPLING requirements are met.

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|---|--|-----------------|
| A. Number of instrument channels FUNCTIONAL less than required by Table 12.2-2. | A.1 Enter the Condition referenced in Table 12.2-2 for the instrument channel. | Immediately |
| B. Radioactive gaseous effluent monitoring instrument channel alarm setpoint less conservative than required. | B.1 Suspend the release of radioactive gaseous effluents monitored by the affected instrument channel. | Immediately |
| | <u>OR</u> | |
| | B.2 Declare the affected instrument channel non-functional. | Immediately |
| | <u>OR</u> | |
| | B.3 Change the affected instrument channel setpoint so it is acceptably conservative. | Immediately |

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(continued)

ACTIONS (continued)

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|--|---|-------------------------|
| <p>C. As required by Required Action A.1 and referenced in Table 12.2-2.</p> | <p>C.1.1 Verify at least one Reactor Building Vent Exhaust Duct Radiation Monitor is FUNCTIONAL in each affected pathway.</p> | <p>Immediately</p> |
| | <p><u>OR</u></p> <p>C.1.2 Suspend release of radioactive effluents via this pathway.</p> | <p>Immediately</p> |
| | <p><u>AND</u></p> <p>C.2 Restore instrument channel to FUNCTIONAL status.</p> | <p>30 days</p> |
| <p>D. As required by Required Action A.1 and referenced in Table 12.2-2.</p> | <p>D.1 Establish CONTINUOUS SAMPLING with auxiliary sampling equipment as required in Table 12.4-1.</p> | <p>Immediately</p> |
| | <p><u>AND</u></p> <p>D.2 Restore instrument channel to FUNCTIONAL status.</p> | <p>30 days</p> |
| <p>E. As required by Required Action A.1 and referenced in Table 12.2-2.</p> | <p>E.1 Estimate flow rate.</p> | <p>Once per 4 hours</p> |
| | <p><u>AND</u></p> <p>E.2 Restore instrument channel to FUNCTIONAL status.</p> | <p>30 days</p> |

(continued)

ACTIONS (continued)

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|--|---|--|
| <p>I. -----NOTE----- Required Action I.1 shall be completed if this condition is entered. ----- Required ACTION and associated Completion Time of Condition H.2 not met.</p> | <p>I.1 Prepare and submit a written report to the NRC outlining the plans, actions taken, and procedures used to provide for the loss of sampling capability.</p> | <p>30 days</p> |
| <p>J. As required by Required Action A.1 and referenced in Table 12.2-2.</p> | <p>J.1.1 Restore instrument channel to FUNCTIONAL status. <u>AND</u> J.1.2 Verify affected offgas treatment system is NOT bypassed. <u>AND</u> J.1.3 Verify Unit 2/3 Chimney Monitoring requirements of Table 12.2-2 are met. <u>AND</u> J.2 Restore instrument channel to FUNCTIONAL status.</p> | <p>72 hours Immediately Immediately 30 days</p> |
| <p>K. Required Action J.1 and associated Completion Time not met.</p> | <p>K.1 Place the affected unit in at least HOT STANDBY.</p> | <p>12 hours</p> |
| <p>L. Required Action C.2, D.2, E.2, F.2, G.2, H.2, or J.2 and associated Completion Time not met.</p> | <p>L.1 Explain why the loss of functionality was not corrected in a timely manner in the Radioactive Effluent Release Report.</p> | <p>In accordance with Units 2/3 TS 5.6.3 or Unit 1 TS 6.9.A.4.</p> |

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12.2.2 SURVEILLANCE REQUIREMENTS

-----NOTE-----

CHANNEL CHECK, CHANNEL FUNCTIONAL TEST, and CHANNEL CALIBRATION are not required when the instruments are NOT required to be FUNCTIONAL or are tripped.

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| SURVEILLANCE REQUIREMENT | | FREQUENCY |
|--------------------------|--|-----------|
| RSR 12.2.2.1 | Perform CHANNEL CHECK. | 24 hours |
| RSR 12.2.2.2 | Perform CHANNEL CHECK to verify FUNCTIONALITY of the sampler; that the sampler is in place and functioning properly. | 24 hours |
| RSR 12.2.2.3 | Perform SOURCE CHECK. | 31 days |
| RSR 12.2.2.4 | Perform SOURCE CHECK. | 24 months |
| RSR 12.2.2.5 | Perform CHANNEL FUNCTIONAL TEST, which shall also demonstrate that control room annunciation occurs if any of the following conditions exist: <ol style="list-style-type: none"> 1. Instrument indicates measured levels above the Alarm setpoint, or 2. Circuit failure, or 3. Instrument indicates a downscale failure, or 4. Instrument controls not set in Operate mode. | 92 days |
| RSR 12.2.2.6 | Perform CHANNEL CALIBRATION, which shall include performance of a CHANNEL FUNCTIONAL TEST. | 18 months |
| RSR 12.2.2.7 | Perform CHANNEL CALIBRATION, which shall include performance of a CHANNEL FUNCTIONAL TEST. | 24 months |

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Table 12.2-2 (Page 1 of 3)
RADIOACTIVE GASEOUS EFFLUENT MONITORING INSTRUMENTATION

| INSTRUMENT | APPLICABLE MODES OR OTHER SPECIFIED CONDITION | REQUIRED CHANNELS PER INSTRUMENT | CONDITION REFERENCED FROM REQUIRED ACTION A.1 | SURVEILLANCE REQUIREMENTS |
|--|---|---|---|--|
| 1. 2/3 Reactor Building Ventilation System | | | | |
| a. Unit 2/3 Reactor Building Vent Monitoring SPING | | | | |
| 1) Noble Gas Monitor Low, Mid, High Range | (a) | 1 | C | RSR 12.2.2.1 RSR 12.2.2.3 RSR 12.2.2.5 RSR 12.2.2.6 |
| 2) Iodine Sampler | (a) | 1 | D | RSR 12.2.2.2 |
| 3) Particulate Sampler | (a) | 1 | D | RSR 12.2.2.2 |
| 4) System Flow Rate Monitor | (a) | 1 | E | RSR 12.2.2.1 RSR 12.2.2.5 RSR 12.2.2.7 |
| 5) Sampler Flow Rate Monitor | (a) | 1 | E | RSR 12.2.2.1 RSR 12.2.2.5 ^(e) RSR 12.2.2.7 |
| b. Unit 2 Reactor Building Vent Monitoring | | | | |
| 1) Exhaust Duct Radiation Monitor | | Per Technical Specification 3.3.6.2 | | |
| 2) Iodine Sampler | (b) | 1 | D | RSR 12.2.2.2 |
| 3) Particulate Sampler | (b) | 1 | D | RSR 12.2.2.2 |
| 4) Sampler Flow Rate Monitor | (b) | 1 | E | RSR 12.2.2.1 RSR 12.2.2.5 ^(e) RSR 12.2.2.7 |
| c. Unit 3 Reactor Building Vent Monitoring | | | | |
| 1) Exhaust Duct Radiation Monitor | | Per Technical Specification 3.3.6.2 | | |
| 2) Iodine Sampler | (b) | 1 | D | RSR 12.2.2.2 |
| 3) Particulate Sampler | (b) | 1 | D | RSR 12.2.2.2 |
| 4) Sampler Flow Rate Monitor | (b) | 1 | E | RSR 12.2.2.1 RSR 12.2.2.5 ^(e) RSR 12.2.2.7 |

(continued)

- (a) At all times.
 (b) During effluent releases via this pathway when the 2/3 Reactor Building Vent SPING Iodine or Particulate Sampler is non-functional.
 (e) CHANNEL FUNCTIONAL TEST shall be performed on local switches providing low flow alarm.

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Table 12.2-2 (Page 2 of 3)
RADIOACTIVE GASEOUS EFFLUENT MONITORING INSTRUMENTATION

| INSTRUMENT | APPLICABLE MODES OR OTHER SPECIFIED CONDITION | REQUIRED CHANNELS PER INSTRUMENT | CONDITION REFERENCED FROM REQUIRED ACTION A.1 | SURVEILLANCE REQUIREMENTS |
|---|---|----------------------------------|---|--|
| 2. Main Stack System | | | | |
| a. Unit 1 Chimney Monitoring | | | | |
| 1) Iodine Sampler | (f) | 1 | D | RSR 12.2.2.2 |
| 2) Particulate Sampler | (f) | 1 | D | RSR 12.2.2.2 |
| b. Unit 2/3 Chimney Monitoring | | | | |
| 1) SPING / GE Noble Gas Monitor Low Range (3 channels available) | (a) | 1 | G | RSR 12.2.2.1 RSR 12.2.2.3 RSR 12.2.2.5 RSR 12.2.2.6 |
| 2) SPING Noble Gas Monitor Mid, High Range | (a) | 1 | H | RSR 12.2.2.1 RSR 12.2.2.3 RSR 12.2.2.5 RSR 12.2.2.6 |
| 3) Iodine Sampler | (a) | 1 | D | RSR 12.2.2.2 |
| 4) Particulate Sampler | (a) | 1 | D | RSR 12.2.2.2 |
| 5) System Flow Rate Monitor | (a) | 1 | E | RSR 12.2.2.1 RSR 12.2.2.5 RSR 12.2.2.7 |
| 6) Sampler Flow Rate Monitor | (a) | 1 | E | RSR 12.2.2.1 RSR 12.2.2.5 ^(e) RSR 12.2.2.7 |

(continued)

- (a) At all times.
- (e) CHANNEL FUNCTIONAL TEST shall be performed on local switches providing low flow alarm.
- (f) During operation of the Unit 1 Gaseous Monitoring System.

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Table 12.2-2 (Page 3 of 3)
RADIOACTIVE GASEOUS EFFLUENT MONITORING INSTRUMENTATION

| INSTRUMENT | APPLICABLE MODES OR OTHER SPECIFIED CONDITION | REQUIRED CHANNELS PER INSTRUMENT | CONDITION REFERENCED FROM REQUIRED ACTION A.1 | SURVEILLANCE REQUIREMENTS |
|--|---|---|---|--|
| 3. Condenser Air Ejector Radioactivity Monitor (Prior to Input to Holdup System) | | | | |
| a. Unit 2 Offgas Recombiner Outlet Monitoring | | | | |
| 1) Radiation Activity Monitor (2 channels available) | (c) | 1 | J | RSR 12.2.2.1 RSR 12.2.2.4 RSR 12.2.2.5 RSR 12.2.2.7 |
| b. Unit 3 Offgas Recombiner Outlet Monitoring | | | | |
| 1) Radiation Activity Monitor (2 channels available) | (c) | 1 | J | RSR 12.2.2.1 RSR 12.2.2.4 RSR 12.2.2.5 RSR 12.2.2.7 |
| 4. Decontamination Building Ventilation System | | | | |
| a. Unit 1 Chemical Cleaning Building Monitoring | | | | |
| 1) Iodine Sampler | (d) | 1 | D | RSR 12.2.2.2 |
| 2) Particulate Sampler | (d) | 1 | D | RSR 12.2.2.2 |

(c) During operation of the Steam Jet Air Ejector for the applicable unit.

(d) During operation of Chemical Cleaning Building or Interim Radwaste Storage Facility ventilation system.

12.3 LIQUID EFFLUENTS

12.3.1 LIQUID EFFLUENT CONCENTRATION

REC 12.3.1 The maximum concentration of radioactive material released in liquid effluents to UNRESTRICTED AREAS (see Part II Figure 1-3) shall be limited to:

- a. 10 times the concentration specified in 10 CFR 20 Appendix B, Table 2, Column 2 for radionuclides other than dissolved or entrained noble gases;
AND
- b. 2×10^{-4} microCurie/ml total activity for all dissolved or entrained noble gases.

APPLICABILITY: At all times.

ACTIONS

-----NOTE-----

The provisions of REC 12.0.3 and REC 12.0.4 are not applicable.

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|--|---|--|
| A. -----NOTE----- Required Action A.2 shall be completed if this condition is entered. ----- Concentration of radioactive material released to UNRESTRICTED AREAS exceeding limits of REC 12.3.1. | A.1 Restore the concentration of radioactive material to within limits (decrease release rate and / or increase dilution flow). <u>AND</u> A.2 Notify the NRC as required by 10 CFR 20.2203 | Immediately 30 days |

12.3.1 SURVEILLANCE REQUIREMENTS

| SURVEILLANCE REQUIREMENT | FREQUENCY |
|--|---------------------------------|
| RSR 12.3.1.1 Perform representative radioactive liquid sampling. | In accordance with Table 12.3-2 |
| RSR 12.3.1.2 Perform radioactive liquid activity analysis. | In accordance with Table 12.3-2 |
| RSR 12.3.1.3 Evaluate each liquid radwaste effluent batch using the calculational methods of the ODCM to ensure concentrations are within the limits of REC 12.3.1. Base the release rate on the circulating water flow rate at the time of discharge. | Prior to each release |

Table 12.3-1

Table deleted.

Table 12.3-2
RADIOACTIVE LIQUID WASTE SAMPLING AND ANALYSIS PROGRAM
(Page 1 of 3)

| LIQUID RELEASE TYPE | MINIMUM SAMPLING REQUIREMENTS ⁽¹⁾ | MINIMUM ANALYSIS FREQUENCY ⁽¹⁾ | TYPE OF ACTIVITY ANALYSIS | LOWER LIMIT OF DETECTION (LLD) ⁽²⁾ (μCi/ml) |
|--|--|---|--|--|
| A. Batch Release Tanks ⁽³⁾ (Units 2, 3 only) | Prior to release, each batch | Prior to release, each batch | Principal Gamma Emitters ⁽⁴⁾ | 5×10^{-7} |
| | | | I-131 | 1×10^{-6} |
| | | | H-3 | 1×10^{-5} |
| | Prior to release, one batch per 31 days | 31 days | Dissolved & Entrained Gases ⁽⁵⁾ (Gamma emitters) | 1×10^{-5} |
| | Prior to release, each batch | 31 days Composite ⁽⁶⁾ | Gross Alpha | 1×10^{-7} |
| | Prior to release, each batch | 92 days Composite ⁽⁶⁾ | Sr-89, Sr-90 | 5×10^{-8} |
| | | | Fe-55 | 1×10^{-6} |
| B. Plant Continuous Releases ⁽⁷⁾ (Units 2, 3 only) | 31 days (Grab Sample) | 31 days | Principal Gamma Emitters ⁽⁴⁾ | 5×10^{-7} |
| | | | I-131 | 1×10^{-6} |
| | | | Dissolved & Entrained Gases ⁽⁵⁾ (Gamma emitters) | 1×10^{-5} |
| | | | H-3 | 1×10^{-5} |
| | 31 days (Grab Sample) | 31 days | Gross Alpha | 1×10^{-7} |
| | 92 days (Grab Sample) | 92 days | Sr-89, Sr-90 | 5×10^{-8} |
| | | | Fe-55 | 1×10^{-6} |
| C. Above Ground Liquid Storage Tanks | See Technical Requirements Manual | See Technical Requirements Manual | Principal Gamma Emitters ⁽⁴⁾ | 5×10^{-7} |
| | | | Dissolved & Entrained Gases ⁽⁵⁾ (Gamma emitters) | 1×10^{-5} |

Table 12.3-2 (Page 2 of 3)
RADIOACTIVE LIQUID WASTE SAMPLING AND ANALYSIS PROGRAM
TABLE NOTATION

- (1) The provisions of RSR 12.0.2 and RSR 12.0.3 are applicable to the Radioactive Liquid Waste Sampling and Analysis Program sampling and analysis frequencies.
- (2) The LLD is defined, for purposes of these specifications, as the smallest concentration of radioactive material in a sample that will yield a net count, above system background, that will be detected with 95% probability with only 5% probability of falsely concluding that a blank observation represents a "real" signal.

For a particular measurement system, which may include radiochemical separation:

$$LLD = \frac{4.66s_b}{E \cdot V \cdot 2.22 \times 10^6 \cdot Y \cdot e^{-\lambda \Delta t}}$$

Where:

LLD = the lower limit of detection (microcuries per unit mass or volume),

4.66 = $2k\sqrt{2}$, where k is the statistical student's "t" factor for a one-tailed distribution with infinite degrees of freedom at a confidence level of 95%,

s_b = the standard deviation of the background counting rate or of the counting rate of a blank sample as appropriate (counts per minute),

$$= \frac{\sqrt{\text{Total Counts}}}{t_b}$$

t_b = background counting time (minutes)

E = the counting efficiency (counts per disintegration),

V = the sample size (units of mass or volume),

2.22×10^6 = the number of disintegrations per minute per microcuries,

Y = the fractional radiochemical yield, when applicable,

λ = the radioactive decay constant for the particular radionuclide (sec^{-1}), and

Δt = the elapsed time between the midpoint of sample collection and the time of counting (sec).

Typical values of E, V, Y, and Δt should be used in the calculation.

It should be recognized that the LLD is defined as an a priori (before the fact) limit representing the capability of the measurement system and not as an a posteriori (after the fact) limit for a particular measurement.

- (3) A batch release is the discharge of liquid wastes of a discrete volume. Prior to sampling for analyses, each batch shall be isolated and then thoroughly mixed to assure representative sampling.

Table 12.3-2 (Page 3 of 3)

RADIOACTIVE LIQUID WASTE SAMPLING AND ANALYSIS PROGRAM
TABLE NOTATION

- (4) The principal gamma emitters for which the LLD control applies are the following radionuclides: Mn-54, Fe-59, Co-58, Co-60, Zn-65, Mo-99, Cs-134, Cs-137, and Ce-141. Ce-144 shall also be measured, but with an LLD of 5×10^{-6} . This list does not mean that only these nuclides are to be considered. Other gamma peaks that are identifiable, together with those of the above nuclides, shall also be analyzed and reported in the Radioactive Effluent Release Report.
- (5) The dissolved and entrained gases (gamma emitters) for which the LLD specification applies are the following radionuclides: Kr-87, Kr-88, Xe-133, Xe-133m, Xe-135, and Xe-138. This list does not mean that only these nuclides are to be considered. Other gamma peaks that are identifiable, together with those of the above nuclides, shall also be analyzed and reported.
- (6) A composite sample is one in which the quantity of liquid sampled is proportional to the quantity of liquid waste discharged and in which the method of sampling employed results in a specimen that is representative of the liquids released.
- (7) A continuous release is the discharge of liquid wastes of a non-discrete volume; e.g., from a volume or system that has an input flow during the continuous release.

12.3 LIQUID EFFLUENTS

12.3.2 DOSE FROM LIQUID EFFLUENTS

REC 12.3.2.1 The dose or dose commitment to a MEMBER OF THE PUBLIC from radioactive material in liquid effluents released, from each unit, to UNRESTRICTED AREAS shall be limited to:

- a. ≤ 1.5 mrem to the total body and ≤ 5.0 mrem to any organ during any calendar quarter; and
- b. ≤ 3.0 mrem to the total body and ≤ 10.0 mrem to any organ during any calendar year.

REC 12.3.2.2 The projected annual total body or any internal organ dose calculated at the nearest downstream community water system from all radioactive material in liquid effluents released from the station shall be limited to <2.0 mrem.

APPLICABILITY: At all times.

ACTIONS

-----NOTE-----

The provisions of REC 12.0.3 and REC 12.0.4 are not applicable.

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|--|---|-----------------|
| A. Calculated dose or dose commitment exceeds two times (2x) limits of REC 12.3.2.1.a or b. | A.1 Enter condition A of 12.5.1. | Immediately |
| B. -----NOTE----- Required Action B.1 shall be completed if this condition is entered. ----- Projected dose at the nearest downstream community water system exceeds required limits of REC 12.3.2.2. | B.1 Submit a report to the community water system operator, with copy to the NRC, to assist the operator in meeting 40 CFR 141, EPA Primary Drinking Water Standards. | 30 days |

(continued)

ACTIONS (continued)

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|--|--|--|
| <p>C. -----NOTE----- Required Action C.1 shall be completed if this condition is entered. ----- Calculated dose or dose commitment from the release of radioactive materials in liquid effluents exceeds required limits of REC 12.3.2.1.a or b.</p> | <p>C.1 Submit a Special Report, pursuant to 10CFR50 Appendix I, Section IV.A to the NRC that identifies the cause(s) for exceeding limits, corrective actions taken to reduce releases of radioactive materials in liquid effluents, and proposed actions taken to assure future releases are in compliance with REC 12.3.2.1.a and b.</p> | <p>30 days from the end of the quarter during which the release occurred</p> |

12.3.2 SURVEILLANCE REQUIREMENTS

-----NOTES-----

1. Only required to be performed if liquid releases have occurred since the last performance of these RSRs.
2. RSR 12.0.2 is not applicable

| SURVEILLANCE REQUIREMENT | FREQUENCY |
|--|-----------|
| <p>RSR 12.3.2.1 Determine cumulative dose contributions from liquid effluents for the current calendar quarter and the current calendar year in accordance with the methodology and parameters in the ODCM.</p> | 31 days |
| <p>RSR 12.3.2.2 Determine projected dose contributions from liquid effluents in accordance with the methodology in the ODCM.</p> | 31 days |
| <p>RSR 12.3.2.3 Determine cumulative and projected dose contributions from liquid effluents at the nearest community water system considering only the drinking water pathway in accordance with the methodology and parameters in the ODCM.</p> | 92 days |

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12.3 LIQUID EFFLUENTS

12.3.3 LIQUID RADWASTE TREATMENT SYSTEMS

REC 12.3.3 The Liquid Radwaste Treatment System shall be FUNCTIONAL and appropriate portions of the system shall be used to reduce releases of radioactivity when the projected doses due to the liquid effluent, from each unit, to UNRESTRICTED AREAS would exceed:

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- a. ≤ 0.06 mrem to the total body, or
- b. ≤ 0.2 mrem to any organ

in a 31-day period, which is 2% of annual guidelines of 10 CFR 50, Appendix I.

APPLICABILITY: At all times.

ACTIONS

NOTES

The provisions of REC 12.0.3 and REC 12.0.4 are not applicable.

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|---|---|-----------------|
| <p>A. -----NOTE----- Required Action A.1 shall be completed if this condition is entered. ----- Radioactive liquid waste being discharged without treatment and in excess of the limits of REC 12.3.3 and any portion of the Liquid Radwaste Treatment System not in operation.</p> | <p>A.1 Submit a Special Report to the NRC that includes an explanation of why liquid radwaste was discharged without treatment, identification of non-functional equipment or subsystems, and the reason for the loss of FUNCTIONALITY, action(s) taken to restore the non-functional equipment to FUNCTIONAL status, summary description of action(s) taken to prevent recurrence, and duration, volume, and curie content of the release.</p> | <p>30 days</p> |

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12.3.3 SURVEILLANCE REQUIREMENTS

| SURVEILLANCE REQUIREMENT | FREQUENCY |
|--------------------------|-----------|
|--------------------------|-----------|

NOTES

1. Liquid Radwaste Treatment System shall be considered FUNCTIONAL by meeting REC 12.3.1 and REC 12.3.2.1.a and b.
2. Dose projections are performed per RSR 12.3.2.2.

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12.4 GASEOUS EFFLUENTS

12.4.1 GASEOUS EFFLUENT DOSE RATES

REC 12.4.1 The dose rate due to radioactive materials released in gaseous effluents from the site to areas at and beyond the SITE BOUNDARY shall be limited to the following:

- a. For noble gases: ≤ 500 mrem/year to the total body and ≤ 3000 mrem/year to the skin; and
- b. For Iodine-131, for Iodine-133, for tritium, and for all radionuclides in particulate form with half-lives greater than 8 days: ≤ 1500 mrem/year to any organ.

APPLICABILITY: At all times.

ACTIONS

-----NOTE-----

The provisions of REC 12.0.3 and REC 12.0.4 are not applicable.

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|--|--|----------------------------|
| A. Dose rates due to radioactive material in gaseous effluents at or beyond the SITE BOUNDARY exceed limits of REC 12.4.1. | A.1 Restore release rate to within REC 12.4.1 limits. <u>AND</u> A.2 Notify the NRC as required by 10 CFR 20.2203. | Immediately 30 days |

12.4.1 SURVEILLANCE REQUIREMENTS

| SURVEILLANCE REQUIREMENT | FREQUENCY |
|---|---------------------------------|
| RSR 12.4.1.1 Determine the dose rate due to radioactive materials in the form of noble gases, I-131, I-133, tritium, and particulates with half lives > 8 days released in gaseous effluents from the site is within the prescribed limits in accordance with methodology and parameters in the ODCM by obtaining representative samples and performing analyses. | In accordance with Table 12.4-1 |

Table 12.4-1 (Page 1 of 3)
RADIOACTIVE GASEOUS WASTE SAMPLING AND ANALYSIS PROGRAM

| GASEOUS RELEASE TYPE | SAMPLING FREQUENCY ⁽¹⁾ | MINIMUM ANALYSIS FREQUENCY ⁽¹⁾ | TYPE OF ACTIVITY ANALYSIS | LOWER LIMIT OF DETECTION (LLD) ⁽²⁾ (µCi/ml) |
|--|---------------------------------------|---|--|--|
| A. 2/3 Chimney and 2/3 Reactor Building Ventilation Stack | 31 days ⁽³⁾ Grab Sample | 31 days | Principal Gamma Emitters ⁽⁴⁾ | 1x10 ⁻⁴ |
| | Continuous ⁽⁵⁾ | Noble Gas Monitor | Noble Gases | 1x10 ⁻⁶ |
| B. 2/3 Chimney and 2/3 Reactor Building Ventilation Stack | 31 days Grab Sample | 31 days | Tritium (oxide) | 1x10 ⁻⁶ |
| C. 1 Chimney ⁽⁹⁾ , 1 Chemical Cleaning Building Stack ⁽⁶⁾ , 2/3 Chimney, and 2/3 Reactor Building Ventilation Stack | Continuous ⁽⁵⁾ | 7 days ⁽⁷⁾ Charcoal Sample | I-131 | 1x10 ⁻¹² |
| | | | I-133 | 1x10 ⁻¹⁰ |
| | Continuous ⁽⁵⁾ | 7 days ⁽⁷⁾ Particulate Sample | Principal Gamma Emitters ⁽⁴⁾ | 1x10 ⁻¹¹ |
| | Continuous ⁽⁵⁾ | 92 days Composite Particulate Sample | Sr-89, Sr-90 Gross Alpha ⁽⁸⁾ | 1x10 ⁻¹¹ |

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Table 12.4-1 (Page 2 of 3)

RADIOACTIVE GASEOUS WASTE SAMPLING
AND ANALYSIS PROGRAM

TABLE NOTATION

- (1) The provisions of RSR 12.0.2 and RSR 12.0.3 are applicable to the Radioactive Gaseous Waste Sampling and Analysis Program sampling and analysis frequencies.
- (2) The LLD is defined, for purposes of these specifications, as the smallest concentration of radioactive material in a sample that will yield a net count, above system background, that will be detected with 95% probability with only 5% probability of falsely concluding that a blank observation represents a "real" signal.

For a particular measurement system, which may include radiochemical separation:

$$LLD = \frac{4.66s_b}{E \cdot V \cdot 2.22 \times 10^6 \cdot Y \cdot e^{-\lambda \Delta t}}$$

Where:

LLD = the lower limit of detection (microcuries per unit mass or volume),

4.66 = $2k\sqrt{2}$, where k is the statistical student's "t" factor for a one-tailed distribution with infinite degrees of freedom at a confidence level of 95%,

s_b = the standard deviation of the background counting rate or of the counting rate of a blank sample as appropriate (counts per minute),

$$= \frac{\sqrt{\text{Total Counts}}}{t_b}$$

t_b = background counting time (minutes)

E = the counting efficiency (counts per disintegration),

V = the sample size (units of mass or volume),

2.22×10^6 = the number of disintegrations per minute per microcuries,

Y = the fractional radiochemical yield, when applicable,

λ = the radioactive decay constant for the particular radionuclide (sec^{-1}), and

Δt = the elapsed time between the midpoint of sample collection and the time of counting (sec).

Typical values of E, V, Y, and Δt should be used in the calculation.

It should be recognized that the LLD is defined as an a priori (before the fact) limit representing the capability of the measurement system and not as an a posteriori (after the fact) limit for a particular measurement.

Table 12.4-1 (Page 3 of 3)

RADIOACTIVE GASEOUS WASTE SAMPLING
AND ANALYSIS PROGRAM

TABLE NOTATION

- (3) Noble gas sampling and analyses of the 1) 2/3 Reactor Building Ventilation Stack or the affected unit Reactor Building Ventilation system and 2) 2/3 Chimney shall also be performed following shutdown, startup, or a thermal power change exceeding 20% RTP within a 1-hour period unless 1) analysis shows that the DOSE EQUIVALENT I-131 concentration in the primary coolant has not increased more than a factor of 5, and 2) the noble gas activity monitor shows that effluent activity has not increased by more than a factor of 3.
- (4) The principal gamma emitters for which the LLD specification applies are the following radionuclides: Kr-87, Kr-88, Xe-133, Xe-133m, Xe-135, and Xe-138 for gaseous emissions, and Mn-54, Fe-59, Co-58, Co-60, Zn-65, Mo-99, Cs-134, Cs-137, Ce-141, and Ce-144 for particulate emissions. Other peaks that are measurable and identifiable by gamma ray spectrometry, together with the above nuclides, shall be also identified and reported when an actual analysis is performed on a sample.
- (5) The ratio of sample flow rate to the sampled stream flow rate or to the system design flow rate shall be known for the time period covered by each dose or dose rate calculation made in accordance with REC 12.4.1, REC 12.4.2, and REC 12.4.3.
- (6) Sampling of the Chemical Cleaning Building Stack is not required if the Chemical Cleaning and Interim Radwaste Storage Facility (IRSF) ventilation systems are not running.
- (7) Samples shall be changed at least once per 7 days and the analyses completed within 48 hours after changing, or after removal from sampler. Sampling of the 1) 2/3 Reactor Building Ventilation Stack or the affected unit Reactor Building Ventilation system and 2) 2/3 Chimney shall also be performed within 24 hours following each shutdown, startup, or thermal power level change exceeding 20% RTP within a 1-hour period and analyses shall be completed within 48 hours of changing. This requirement does not apply if 1) analysis shows that the DOSE EQUIVALENT I-131 concentration in the primary coolant has not increased more than a factor of 5, and 2) the noble gas activity monitor shows that effluent activity has not increased by more than a factor of 3. When samples collected for 24 hours or less are analyzed, the corresponding LLDs may be increased by a factor of 10.
- (8) For radionuclides not determined in each batch or weekly composite, the dose contribution to the current calendar quarter or calendar year cumulative summation may be estimated by assuming an average monthly concentration based on the previous monthly or quarterly composite analyses. However, for reporting purposes, the calculated dose contributions shall be based on the actual composite analyses when possible.
- (9) Sampling of the Unit 1 Chimney is not required if the Unit 1 Gaseous Monitoring System is not discharging via the Unit 1 Chimney.

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12.4 GASEOUS EFFLUENTS

12.4.2 DOSE FROM NOBLE GASES

REC 12.4.2 The air dose due to noble gases released in gaseous effluents, from each unit, to areas at or beyond the SITE BOUNDARY shall be limited to the following:

- a. For gamma radiation, ≤ 5 mrad during any calendar quarter;
- b. For beta radiation, ≤ 10 mrad during any calendar quarter;
- c. For gamma radiation, ≤ 10 mrad during any calendar year; and
- d. For beta radiation, ≤ 20 mrad during any calendar year.

APPLICABILITY: At all times.

ACTIONS

-----NOTE-----

The provisions of REC 12.0.3 and REC 12.0.4 are not applicable.

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|--|--|---|
| A. Calculated dose or dose commitment exceeds two times (2x) limits of REC 12.4.2. | A.1 Enter condition A of 12.5.1. | Immediately |
| B. -----NOTE----- Required Action A.1 shall be completed if this condition is entered. ----- Calculated air dose at or beyond the SITE BOUNDARY from radioactive noble gases in gaseous effluents exceeds limits. | B.1 Submit a Special Report, pursuant to 10CFR50 Appendix I, Section IV.A to the NRC that identifies cause(s) for exceeding the limit(s), defines the corrective actions taken to reduce the releases, and the proposed corrective actions to assure that subsequent releases are within limits. | 30 days from the end of the quarter during which the release occurred |

12.4.2 SURVEILLANCE REQUIREMENTS

-----NOTE-----

RSR 12.0.2 is not applicable.

| SURVEILLANCE REQUIREMENT | FREQUENCY |
|---|-----------|
| RSR 12.4.2.1 Determine cumulative dose contributions for the current calendar quarter and current calendar year from noble gases in accordance with the methodology and parameters in the ODCM. | 31 days |
| RSR 12.4.2.2 Determine projected dose contributions for noble gases in accordance with the methodology in the ODCM. | 31 days |

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12.4 GASEOUS EFFLUENTS

12.4.3 DOSE FROM IODINE-131, IODINE-133, TRITIUM, AND RADIOACTIVE MATERIALS IN PARTICULATE FORM

REC 12.4.3 The dose to a MEMBER OF THE PUBLIC from iodine-131, iodine-133, tritium and all radionuclides in particulate form with half lives > 8 days in gaseous effluents released, from each unit, to areas at or beyond the SITE BOUNDARY shall be limited to:

- a. ≤ 7.5 mrem to any organ during any calendar quarter; and
- b. ≤ 15 mrem to any organ during any calendar year.

APPLICABILITY: At all times.

ACTIONS

-----NOTE-----

The provisions of REC 12.0.3 and REC 12.0.4 are not applicable.

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|---|---|---|
| A. Calculated dose or dose commitment exceeds two times (2x) limits of REC 12.4.3. | A.1 Enter condition A of 12.5.1. | Immediately |
| B. -----NOTE----- Required Action A.1 shall be completed if this condition is entered. ----- Calculated dose from the release of iodine-131, iodine-133, tritium, and radionuclides in particulate form, with half-lives > 8 days in gaseous effluents exceeds limits. | B.1 Submit a Special Report, pursuant to 10CFR50 Appendix I, Section IV.A to the NRC that identifies cause(s) for exceeding limit(s), corrective actions taken, and proposed corrective actions to assure that subsequent releases are within limits. | 30 days from the end of the quarter during which the release occurred |

12.4.3 SURVEILLANCE REQUIREMENTS

-----NOTE-----

RSR 12.0.2 is not applicable

| SURVEILLANCE REQUIREMENT | FREQUENCY |
|---|-----------|
| RSR 12.4.3.1 Determine cumulative dose contributions for the current calendar quarter and current calendar year from iodine-131, iodine-133, tritium, and radionuclides in particulate form with half-lives > 8 days in accordance with the methodology and parameters in the ODCM. | 31 days |
| RSR 12.4.3.2 Determine projected dose contributions from iodine-131, iodine-133, tritium, and radionuclides in particulate form with half-lives > 8 days in accordance with the methodology in the ODCM. | 31 days |

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12.4 GASEOUS EFFLUENTS

12.4.4 GASEOUS RADWASTE TREATMENT SYSTEM

REC 12.4.4 The GASEOUS RADWASTE TREATMENT SYSTEM shall be in operation.

APPLICABILITY: Whenever the Main Condenser Air Ejector system is in operation and the unit is above 30% RTP.

ACTIONS

-----NOTE-----

The provisions of REC 12.0.3 and REC 12.0.4 are not applicable.

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|---|--|-----------------|
| <p>A. -----NOTE----- Required Action A.1 shall be completed if this condition is entered. ----- Gaseous radwaste from the main condenser air ejector system is being discharged without treatment (i.e., all charcoal beds) for more than 7 days in a calendar quarter.</p> | <p>A.1 Submit a Special Report to the NRC that includes identification of non-functional equipment or subsystems and reason for loss of FUNCTIONALITY, action(s) taken to restore the non-functional equipment to FUNCTIONAL status, length of time REC 12.4.4 was not met, waste discharge volume and curie content that was not processed but required processing, and summary description of action(s) taken to prevent a recurrence.</p> | <p>30 days</p> |

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12.4.4 SURVEILLANCE REQUIREMENTS

| SURVEILLANCE REQUIREMENT | FREQUENCY |
|--------------------------|-----------|
|--------------------------|-----------|

-----NOTE-----

Dose projections for this REC are performed per RSR 12.4.2.2 and RSR 12.4.3.2.

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12.4 GASEOUS EFFLUENTS

12.4.5 VENTILATION EXHAUST TREATMENT SYSTEM

REC 12.4.5 The VENTILATION EXHAUST TREATMENT SYSTEM shall be FUNCTIONAL and appropriate portions of this system shall be used to reduce releases of radioactivity when the projected doses in 31 days due gaseous effluent releases, from each unit, to areas at or beyond the SITE BOUNDARY would exceed:

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- a. 0.2 mrad to air from gamma radiation, or
- b. 0.4 mrad to air from beta radiation, or
- c. 0.3 mrem to any organ of a MEMBER OF THE PUBLIC.

APPLICABILITY: At all times.

ACTIONS

-----NOTE-----

The provisions of REC 12.0.3 and REC 12.0.4 are not applicable.

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|---|--|-----------------|
| <p>A. -----NOTE----- Required Action A.1 shall be completed if this condition is entered. ----- Radioactive gaseous waste discharged without treatment and in excess of the above limits.</p> | <p>A.1 Submit a Special Report to the NRC that includes identification of non-functional equipment or subsystems and reason for loss of FUNCTIONALITY, action(s) taken to restore the non-functional equipment to FUNCTIONAL status, and summary description of action(s) taken to prevent a recurrence.</p> | <p>30 days</p> |

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12.4.5 SURVEILLANCE REQUIREMENTS

| SURVEILLANCE REQUIREMENT | FREQUENCY |
|--------------------------|-----------|
|--------------------------|-----------|

-----NOTES-----

1. The installed VENTILATION EXHAUST TREATMENT SYSTEMS shall be considered FUNCTIONAL by meeting REC 12.4.1, and either REC 12.4.2 or REC 12.4.3.
2. Dose projections for this REC are performed per RSR 12.4.2.2 and RSR 12.4.3.2.

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12.4 GASEOUS EFFLUENTS

12.4.6 MARK I CONTAINMENT

REC 12.4.6 VENTING or PURGING of the containment drywell atmosphere shall meet the requirements of REC 12.4.1, REC 12.4.2, and REC 12.4.3, AND shall be:

a. Through the Reactor Building Ventilation Exhaust System OR Standby Gas Treatment System IF drywell atmosphere activity is:

- i. $< 7.2 \times 10^{-9}$ $\mu\text{Ci/cc}$ I-131 AND
- ii. $< 7.9 \times 10^{-9}$ $\mu\text{Ci/cc}$ beta / gamma (total particulate).

OR

b. Through the Standby Gas Treatment System.

APPLICABILITY: During VENTING or PURGING of the containment drywell.

ACTIONS

-----NOTE-----

The provisions of REC 12.0.3 and REC 12.0.4 are not applicable.

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|---|---|---|
| A. Requirement of REC 12.4.6 not met. | A.1 Suspend VENTING or PURGING of the containment drywell. | Immediately |
| B. Drywell atmosphere activity is $\geq 3.5 \times 10^{-7}$ $\mu\text{Ci/cc}$ I-131 or is $\geq 3.9 \times 10^{-6}$ $\mu\text{Ci/cc}$ beta / gamma (total particulate). | B.1 Verify projected dose due to VENTING or PURGING is within the limits of REC 12.4.1, REC 12.4.2, and REC 12.4.3. | Prior to VENTING or PURGING of containment drywell. |

12.4.6 SURVEILLANCE REQUIREMENTS

| SURVEILLANCE REQUIREMENT | FREQUENCY |
|--|---|
| RSR 12.4.6.1 Verify primary containment VENTING or PURGING is through required effluent release pathway of REC 12.4.6. | Prior to VENTING or PURGING of containment drywell. |

12.5 TOTAL DOSE

12.5.1 40CFR190 DOSE LIMITS FOR MEMBERS OF THE PUBLIC

- REC 12.5.1 The annual (calendar year) dose or dose commitment to any MEMBER OF THE PUBLIC due to releases of radioactivity and to radiation from uranium fuel cycle sources within 8 kilometers shall be:
- a. ≤ 25 mrem to the total body;
 - b. ≤ 75 mrem to the thyroid; and
 - c. ≤ 25 mrem to any other critical organ.

APPLICABILITY: At all times.

ACTIONS

-----NOTE-----

The provisions of REC 12.0.3 and REC 12.0.4 are not applicable.

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|---|--|--------------------|
| <p>A. As required by Required Action A.1 of REC 12.3.2, REC 12.4.2 or REC 12.4.3</p> | <p>-----NOTE----- Calculations shall include direct radiation contributions from the units (including outside storage tanks, etc.). ----- A.1 Determine whether the limits of 12.5.1 have been exceeded.</p> | <p>Immediately</p> |
| <p>B. -----NOTE----- Required Action B.1 shall be completed if this condition is entered. ----- Calculated dose or dose commitment exceeds the limits of 12.5.1.</p> | <p>B.1 Submit a Special Report to the NRC that defines the corrective actions taken to reduce subsequent releases to prevent recurrence of exceeding the limits and includes a schedule for achieving conformance with the limits. The report, as defined in 10 CFR 20.2203, shall include an analysis that estimates the radiation exposure (dose) to a MEMBER OF THE PUBLIC from uranium fuel cycle sources, including all effluent pathways and direct radiation for the calendar year that includes the release(s) covered by this report.</p> | <p>30 days</p> |

(continued)

ACTIONS (Continued)

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|---|--|-----------------|
| <p>C. -----NOTE----- Required Action C.1 shall be completed if this condition is entered. ----- Calculated dose or dose commitment exceeds the limits of 12.5.1 <u>AND</u> the release condition resulting in exceeding 12.5.1 limits is <u>NOT</u> corrected.</p> | <p>C.1 Submit a request to the NRC for a variance in accordance with the provisions of 40 CFR 190 and a request for an exemption from 10 CFR 72.104 as part of the report for Required Action B.1. Submittal of the report as described in this Required Action is considered a timely request, and a variance is granted until staff action on the request is complete.</p> | <p>30 days</p> |

12.5.1 SURVEILLANCE REQUIREMENTS

| SURVEILLANCE REQUIREMENT | FREQUENCY |
|--|-----------|
| -----NOTES----- | |
| <ol style="list-style-type: none"> 1. Surveillance testing for determination of dose contributions from liquid effluents for this REC is performed per RSR 12.3.2.1. 2. Surveillance testing for determination of dose contributions from gaseous effluents for this REC is performed per RSR 12.4.2.1 and RSR 12.4.3.1. 3. Surveillance testing for determination of dose contributions from direct radiation for this REC is performed by REMP TLD monitoring per RSR 12.6.1.2. | |

12.5 TOTAL DOSE

12.5.2 10CFR20 DOSE LIMITS FOR MEMBERS OF THE PUBLIC

REC 12.5.2 Operations shall be conducted such that:

- a. Total Effective Dose Equivalent (TEDE) to individual MEMBERS OF THE PUBLIC does not exceed 100 mrem/year; and
- b. The dose in any unrestricted area from external sources does not exceed 2 mrem in any one hour.

APPLICABILITY: At all times.

ACTIONS

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|--|--|-----------------|
| <p>A. -----NOTE----- Required Action A.1 shall be completed if this Condition is entered. ----- Dose limit of REC Item a exceeded.</p> | <p>A.1 Submit a report to the NRC in accordance with 10 CFR 20.2203.</p> | <p>30 days</p> |
| <p>B. -----NOTE----- Required Action B.1 shall be completed if this Condition is entered. ----- Dose limit of REC Item b exceeded.</p> | <p>B.1 Submit a report to the NRC in accordance with 10 CFR 20.2203.</p> | <p>30 days</p> |

12.5.2 SURVEILLANCE REQUIREMENTS

| SURVEILLANCE | FREQUENCY |
|---|--|
| <p>RSR 12.5.2.1 Calculate the TEDE to individual MEMBERS OF THE PUBLIC in accordance with the ODCM.</p> | <p>As part of the Radioactive Effluent Release Report per Units 2/3 TS 5.6.3 and Unit 1 TS 6.9.A.4</p> |
| <p>RSR 12.5.2.2 Determine and/or evaluate direct radiation exposures in unrestricted areas.</p> | <p>12 months</p> |

12.6 RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

12.6.1 MONITORING PROGRAM

REC 12.6.1 The Radiological Environmental Monitoring Program (REMP) shall be conducted as specified in Table 12.6-1.

APPLICABILITY: At all times.

ACTIONS

-----NOTE-----

The provisions of REC 12.0.3 and REC 12.0.4 are not applicable.

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|--|---|--|
| <p>A. REMP not being conducted as specified in Table 12.6-1</p> | <p>A.1 Submit to the NRC a description of the reasons for not conducting the REMP as required and the plans for preventing a recurrence.</p> | <p>As part of the Annual Radiological Environmental Operating Report per Units 2/3 TS 5.6.2 and Unit 1 TS 6.9.A.3.</p> |
| <p>B. -----NOTE----- Required Action B.1 shall be completed if this condition is entered. ----- Level of radioactivity as the result of plant effluents in an environmental sampling medium at a specified location exceeds the Reporting Levels of Table 12.6-2 when averaged over any calendar quarter.</p> | <p>B.1 Submit a Special Report to the NRC that identifies the cause(s) for exceeding the limit(s) and defines the corrective actions to be taken to reduce radioactive effluents so that the potential annual dose to a MEMBER OF THE PUBLIC is less than the calendar year limits of REC 12.3.2.1, REC 12.4.2, or REC 12.4.3. The methodology and parameters used to estimate the potential annual dose shall be indicated in this report.</p> | <p>30 days</p> |

(continued)

ACTIONS (continued)

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|--|---|-----------------|
| <p>C. -----NOTE----- Required Action C.1 shall be completed if this condition is entered. -----</p> <p>More than one radionuclide in Table 12.6-2 is detected in the sampling medium.</p> <p><u>AND</u></p> $\frac{C(1)}{RL(1)} + \frac{C(2)}{RL(2)} + \dots \geq 1.0$ <p>where: C = concentration RL = reporting level</p> | <p>C.1 Submit a Special Report to the NRC that identifies the cause(s) for exceeding the limit(s) and defines the corrective actions to be taken to reduce radioactive effluents so that the potential annual dose to a MEMBER OF THE PUBLIC is less than the calendar year limits of REC 12.3.2.1, REC 12.4.2, or REC 12.4.3. The methodology and parameters used to estimate the potential annual dose shall be indicated in this report.</p> | <p>30 days</p> |

(continued)

ACTIONS (continued)

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|---|--|---|
| <p>D. -----NOTE----- Required Actions D.1 and D.2 shall be completed if this condition is entered. -----</p> <p>Radionuclides other than those in Table 12.6-2 are detected and the potential annual dose to a MEMBER OF THE PUBLIC is greater than or equal to the calendar year limits of REC 12.3.2.1, or REC 12.4.2, or REC 12.4.3.</p> | <p>-----NOTE----- Only required if the radionuclides detected are the result of plant effluents. -----</p> <p>D.1 Submit a Special Report to the NRC that identifies the cause(s) for exceeding the limit(s) and defines the corrective actions to be taken to reduce radioactive effluents so that the potential annual dose to a MEMBER OF THE PUBLIC is less than the calendar year limits of REC 12.3.2.1, REC 12.4.2, or REC 12.4.3. The methodology and parameters used to estimate the potential annual dose shall be indicated in this report.</p> <p><u>AND</u></p> <p>-----NOTE----- Only required if the radionuclides detected are NOT the result of plant effluents. -----</p> <p>D.2 Report and describe the condition in the Annual Radiological Environmental Operating Report.</p> | <p>30 days</p> <p>As part of the Annual Radiological Environmental Operating Report per Units 2/3 TS 5.6.2 and Unit 1 TS 6.9.A.3.</p> |

(continued)

ACTIONS (continued)

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|--|---|---|
| <p>E. -----NOTE----- Required Actions E.1 and E.2 shall be completed if this condition is entered. -----</p> <p>Milk or fresh leafy vegetation samples unavailable from one or more of the locations required by Table 12.6-1.</p> | <p>-----NOTE----- Specific locations from which samples are unavailable may be deleted from the REMP after completion of Required Action E.1. -----</p> <p>E.1 Identify specific locations for obtaining replacement samples and add them to the REMP.</p> <p><u>AND</u></p> <p>E.2 Submit documentation for a change in the ODCM including a revised figure(s) and table for the ODCM reflecting the new location(s) with supporting information identifying the cause of the unavailability of samples and justifying the selection of the new location(s) for obtaining samples.</p> | <p>30 days</p> <p>As part of the Radioactive Effluent Release Report per Units 2/3 TS 5.6.3 and Unit 1 TS 6.9.A.4</p> |
| <p>F. -----NOTE----- Required Actions F.1 and F.2 shall be completed if this condition is entered. -----</p> <p>It is not possible or practicable to continue to obtain samples of the media of choice at the most desired location or time.</p> | <p>F.1 Choose suitable alternative media and locations for the particular pathway in question and make appropriate substitutions.</p> <p><u>AND</u></p> <p>F.2 Submit documentation for a change in the ODCM including a revised figure(s) and table for the ODCM reflecting the new location(s) with supporting information identifying the cause of the unavailability of samples for the pathway and justifying the selection of the new location(s) for obtaining samples.</p> | <p>30 days</p> <p>As part of the Radioactive Effluent Release Report per Units 2/3 TS 5.6.3 and Unit 1 TS 6.9.A.4</p> |

12.6.1 SURVEILLANCE REQUIREMENTS

| SURVEILLANCE REQUIREMENT | | FREQUENCY |
|--|--|---------------------------------|
| <p style="text-align: center;">-----NOTES-----</p> <p>1. Deviations are permitted from the required sampling schedule if specimens are unobtainable due to hazardous conditions, seasonal unavailability, or malfunction of automatic sampling equipment.</p> <p>2. If equipment malfunction occurs, an effort shall be made to complete corrective actions prior to the end of the next sampling period.</p> <p>-----</p> | | |
| RSR 12.6.1.1 | Collect REMP samples pursuant to Table 12.6-1 from the specific locations given in the Table and figures in the ODCM. | In accordance with Table 12.6-1 |
| RSR 12.6.1.2 | Analyze REMP samples pursuant to the requirements of Table 12.6-1 and the detection capabilities required by Table 12.6-3. | In accordance with Table 12.6-1 |

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RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

| EXPOSURE PATHWAY AND/ OR SAMPLE | NUMBER OF REPRESENTATIVE SAMPLES AND SAMPLE LOCATIONS ⁽¹⁾ | SAMPLING AND COLLECTION FREQUENCY | TYPE AND FREQUENCY OF ANALYSIS |
|------------------------------------|---|-----------------------------------|--------------------------------|
| 1. Direct Radiation ⁽²⁾ | <p>Forty routine monitoring stations, either with two or more dosimeters or with one instrument for measuring and recording dose rate continuously, placed as follows:</p> <p>a. Indicator- Inner Ring</p> <p>One in each meteorological sector, in the general area of the SITE BOUNDARY (within 3.2 km / 2 mi);</p> <p>b. Indicator- Outer Ring</p> <p>One in each meteorological sector, in the 5 to 10 km (3 to 6.2 mi) range; and</p> <p>c. Other</p> <p>One at each Airborne location given in parts 2.a. and 2.b.</p> <p>d. Control</p> <p>One at the Airborne Control location given in part 2.c.</p> | Quarterly | Gamma dose quarterly. |

Table 12.6-1 (Page 2 of 5)

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

| EXPOSURE PATHWAY AND/ OR SAMPLE | NUMBER OF REPRESENTATIVE SAMPLES AND SAMPLE LOCATIONS ⁽¹⁾ | SAMPLING AND COLLECTION FREQUENCY | TYPE AND FREQUENCY OF ANALYSIS |
|---------------------------------|---|---|--|
| 2. Airborne | | | |
| Radioiodine and Particulates | <p>Samples from a total of eight locations:</p> <p>a. Indicator- Near Field</p> <p>Samples from locations within 5 km (3 mi) in four different sectors.</p> <p>b. Indicator- Far Field</p> <p>Samples from locations between 5 and 10 km (3 and 6.2 mi) in four different sectors.</p> <p>c. Control</p> <p>One sample from a control location within 10 to 30 km (6.2 to 18.6 mi).</p> | Continuous sampler operation with sample collection weekly, or more frequently if required due to dust loading. | <p><u>Radioiodine Canister:</u> I-131 analysis weekly.</p> <p><u>Particulate Sampler:</u> Gross beta analysis following filter change;⁽³⁾ and gamma isotopic analysis⁽⁴⁾ of composite (by location) quarterly.</p> |
| 3. Waterborne | | | |
| a. Surface Water ⁽⁵⁾ | <p>a. Indicator</p> <p>One sample downstream</p> <p>b. Control</p> <p>One sample upstream</p> | Composite sample over 1-month period. | Gross beta and gamma isotopic analysis ⁽⁴⁾ monthly. Composite for tritium analysis quarterly. |
| b. Ground/ Well | <p>a. Indicator</p> <p>Samples from one or two sources, only if likely to be affected.⁽⁷⁾</p> | Quarterly | Gamma isotopic ⁽⁴⁾ and tritium analysis quarterly. |

Table 12.6-1 (Page 3 of 5)

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

| EXPOSURE PATHWAY AND/ OR SAMPLE | NUMBER OF REPRESENTATIVE SAMPLES AND SAMPLE LOCATIONS ⁽¹⁾ | SAMPLING AND COLLECTION FREQUENCY | TYPE AND FREQUENCY OF ANALYSIS |
|---------------------------------|---|---|---|
| 3. Waterborne (continued) | | | |
| c. Drinking | <p>a. Indicator</p> <p>One sample from each community drinking water supply that could be affected by the station discharge within 10 km (6.2 mi) downstream of discharge.</p> <p>b. Control</p> <p>One surface water sample upstream of discharge.</p> <p>Note: Currently there are no community drinking water supplies that could be affected by the station discharge within 10 km (6.2 mi) of the station discharge. Therefore, no Drinking Water monitoring is required at this time.</p> | Composite sample over 2-week period ⁽⁶⁾ when I-131 analysis is performed; monthly composite otherwise when monitoring is required. | I-131 ⁽⁴⁾ analysis on each composite when the dose calculated for the consumption of the water is greater than 1 mrem per year ⁽⁸⁾ . Composite for gross beta and gamma isotopic analyses ⁽⁴⁾ monthly. Composite for tritium analysis quarterly. |
| d. Sediment from Shoreline | a. Indicator | Semiannually. | Gamma isotopic analysis ⁽⁴⁾ semiannually. |
| e. Dredging Spoils | a. Indicator | Annually when dredging occurs within the past 12 months. | Gamma isotopic analysis ⁽⁴⁾ annually. |

Table 12.6-1 (Page 4 of 5)

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

| EXPOSURE PATHWAY AND/ OR SAMPLE | NUMBER OF REPRESENTATIVE SAMPLES AND SAMPLE LOCATIONS ⁽¹⁾ | SAMPLING AND COLLECTION FREQUENCY | TYPE AND FREQUENCY OF ANALYSIS |
|---------------------------------|--|---|---|
| 4. Ingestion | | | |
| a. Milk ⁽⁹⁾ | a. Indicator Samples from milking animals from a maximum of three locations within 10 km (6.2 mi) distance. b. Control One sample from milking animals at a control location within 10 to 30 km (6.2 to 18.6 mi). | Semimonthly when animals are on pasture (May through October), monthly at other times (November through April). | Gamma isotopic ⁽⁴⁾ and I-131 ⁽⁴⁾ analysis on each sample. |
| b. Fish | a. Indicator Representative samples of commercially and recreationally important species in vicinity of plant discharge area. b. Control Representative samples of commercially and recreationally important species in areas not influenced by plant discharge. | Two times annually. | Gamma isotopic analysis ⁽⁴⁾ on edible portions |
| c. Food Products | a. Indicator Two representative samples from the principal food pathways grown in each of four major quadrants within 10 km (6.2 mi): <ul style="list-style-type: none"> • At least one root vegetable sample • At least one broad leaf vegetable sample (or vegetation) b. Control Two representative samples similar to indicator samples grown within 15 to 30 km (9.3 to 18.6 mi). | Annually | Gamma isotopic ⁽⁴⁾ analysis on each sample. |

Table 12.6-1 (Page 5 of 5)

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
TABLE NOTATIONS

- (1) Specific parameters of distance and direction from the centerline of the midpoint of the Unit 2 and Unit 3 reactors and additional description where pertinent, shall be provided for each and every sample location in Table 12.6-1 in Part II, Table 6-1 and Figures 6-1 and 6-2, except for vegetation due to location variability. Refer to NUREG-0133, "Preparation of Radiological Effluent Technical Specifications for Nuclear Power Plants," October 1978, and to Radiological Assessment Branch Technical Position, Revision 1, November 1979. All deviations from the sampling schedule shall be documented in the Annual Radiological Environmental Operating Report. It is recognized that, at times, it may not be possible or practical to continue to obtain samples of the media of choice at the most desired location or time. In these instances suitable alternative media and locations may be chosen for the particular pathway in question and appropriate substitutions made within 30 days in the REMP given in the ODCM. Submit in the next Annual Radioactive Effluent Release Report documentation for a change in the ODCM including a revised figure(s) and table for the ODCM reflecting the new location(s) with supporting information identifying the cause of the unavailability of samples for the pathway and justifying the selection of the new location(s) for obtaining samples.
- (2) One or more instruments, such as a pressurized ion chamber, for measuring and recording dose rate continuously may be used in place of, or in addition to, integrating dosimeters. For the purposes of this table, a thermoluminescent dosimeter (TLD) is considered to be one phosphor; two or more phosphors in a packet are considered as two or more dosimeters. Film badges shall not be used as dosimeters for measuring direct radiation. (The 40 locations is not an absolute number. The number of direct radiation monitoring stations may be reduced according to geographical limitations; e.g., at an ocean site, some sectors will be over water so that the number of dosimeters may be reduced accordingly. The frequency of analysis or readout for TLD systems will depend upon the characteristics of the specific system used and should be selected to obtain optimum dose information with minimal fading.)
- (3) Airborne particulate sample filters shall be analyzed for gross beta radioactivity 24 hours or more after sampling to allow for radon and thoron daughter decay. If gross beta activity in air particulate samples is greater than 10 times the yearly mean of control samples, gamma isotopic analysis shall be performed on the individual samples.
- (4) Gamma isotopic analysis means the identification and quantification of gamma emitting radionuclides that may be attributable to the effluents from the facility. I-131 analysis means the use of separation and counting procedures specific to this radionuclide.
- (5) The "upstream sample" shall be taken at a distance beyond significant influence of the discharge. The "downstream" sample shall be taken in an area beyond but near the mixing zone. "Upstream" samples in an estuary must be taken far enough upstream to be beyond the plant influence.
- (6) A composite sample is one in which the quantity (aliquot) of liquid sampled is proportional to the quantity of flowing liquid and in which the method of sampling employed results in a specimen that is representative of the liquid flow.
- (7) Groundwater samples shall be taken when this source is tapped for drinking or irrigation purposes in areas where the hydraulic gradient or recharge properties are suitable for contamination.
- (8) The dose shall be calculated for the maximum organ and age group, using the methodology and parameters in the ODCM.
- (9) If milking animals are not found in the designated indicator locations, or if the owners decline to participate in the REMP, all milk sampling may be discontinued.

Table 12.6-2

REPORTING LEVELS FOR RADIOACTIVITY CONCENTRATIONS IN ENVIRONMENTAL SAMPLES

| ANALYSIS | WATER (pCi/l) | AIRBORNE PARTICULATE OR GASES (pCi/m ³) | FISH (pCi/kg, wet) | MILK (pCi/l) | FOOD PRODUCTS (pCi/kg, wet) |
|-----------|---------------|--|--------------------|--------------|--------------------------------|
| H-3 | 20,000* | | | | |
| Mn-54 | 1,000 | | 30,000 | | |
| Fe-59 | 400 | | 10,000 | | |
| Co-58 | 1,000 | | 30,000 | | |
| Co-60 | 300 | | 10,000 | | |
| Zn-65 | 300 | | 20,000 | | |
| Zr-Nb-95 | 400*** | | | | |
| I-131 | 2** | 0.9 | | 3 | 100 |
| Cs-134 | 30 | 10 | 1,000 | 60 | 1,000 |
| Cs-137 | 50 | 20 | 2,000 | 70 | 2,000 |
| Ba-La-140 | 200*** | | | 300 | |

* For drinking water samples. This is 40 CFR Part 141 value. If no drinking water pathway exists, a value of 30,000 pCi/l may be used.

** If no drinking water pathway exists, a value of 20 pCi/l may be used.

*** Total of parent and daughter.

Table 12.6-3 (Page 1 of 3)

DETECTION CAPABILITIES FOR ENVIRONMENTAL SAMPLE ANALYSIS⁽¹⁾⁽²⁾

LOWER LIMIT OF DETECTION (LLD)⁽³⁾

| ANALYSIS | WATER (pCi/l) | AIRBORNE PARTICULATE OR GASES (pCi/m ³) | FISH (pCi/kg, wet) | MILK (pCi/l) | FOOD PRODUCTS (pCi/kg, wet) | SEDIMENT (pCi/kg, dry) |
|----------------------|---------------|--|-----------------------|--------------|--------------------------------|---------------------------|
| Gross Beta | 4 | 0.01 | | | | |
| H-3 | 2,000 | | | | | |
| Mn-54 | 15 | | 130 | | | |
| Fe-59 | 30 | | 260 | | | |
| Co-58 | 15 | | 130 | | | |
| Co-60 | 15 | | 130 | | | |
| Zn-65 | 30 | | 260 | | | |
| Zr-95 | 30 | | | | | |
| Nb-95 | 15 | | | | | |
| I-131 ⁽⁴⁾ | 1* | 0.07 | | 1 | 60 | |
| Cs-134 | 15 | 0.05 | 130 | 15 | 60 | 150 |
| Cs-137 | 18 | 0.06 | 150 | 18 | 80 | 180 |
| Ba-140 | 60 | | | 60 | | |
| La-140 | 15 | | | 15 | | |

* If no drinking water pathway exists, a value of 15 pCi/l may be used.

Table 12.6-3 (Page 2 of 3)

DETECTION CAPABILITIES FOR ENVIRONMENTAL SAMPLE ANALYSIS
LOWER LIMIT OF DETECTION (LLD)
TABLE NOTATIONS

- (1) This list does not mean that only these nuclides are to be considered. Other peaks that are identifiable, together with those of the above nuclides, shall also be analyzed and reported in the Annual Radiological Environmental Operating Report.
- (2) Required detection capabilities for thermoluminescent dosimeters used for environmental measurements shall be in accordance with the recommendations of Regulatory Guide 4.13.
- (3) The Lower Limit of Detection (LLD) is defined, for purposes of these controls, as the smallest concentration of radioactive material in a sample that will yield a net count, above system background, that will be detected with 95% probability with only 5% probability of falsely concluding that a blank observation represents a "real" signal.

For a particular measurement system, which may include radiochemical separation:

$$LLD = \frac{4.66s_b}{E \cdot V \cdot 2.22 \cdot Y \cdot e^{-\lambda \Delta t}}$$

LLD = the "a priori" lower limit of detection (picoCuries per unit mass or volume),

4.66 = $2k\sqrt{2}$, where k is the statistical student's "t" factor for a one-tailed distribution with infinite degrees of freedom at a confidence level of 95%,

s_b = the standard deviation of the background counting rate or of the counting rate of a blank sample, as appropriate (counts per minute),

$$= \frac{\sqrt{\text{Total Counts}}}{t_b}$$

t_b = background counting time (minutes)

E = the counting efficiency (counts per disintegration),

V = the sample size (units of mass or volume),

2.22 = the number of disintegrations per minute per picoCurie,

Y = the fractional radiochemical yield, when applicable,

λ = the radioactive decay constant for the particular radionuclide (sec^{-1}),

t_b = counting time of the background or blank (minutes), and

Δt = the elapsed time between sample collection or end of the sample collection period, and the time of counting (sec).

Typical values of E, V, Y, and Δt should be used in the calculation.

Table 12.6-3 (Page 3 of 3)

DETECTION CAPABILITIES FOR ENVIRONMENTAL SAMPLE ANALYSIS⁽¹⁾
LOWER LIMIT OF DETECTION (LLD)⁽²⁾⁽³⁾
TABLE NOTATIONS

It should be recognized that the LLD is defined as an a priori (before the fact) limit representing the capability of a measurement system and not as an a posteriori (after the fact) limit for a particular measurement.

Analyses shall be performed in such a manner that the stated LLDs will be achieved under routine conditions. Occasionally background fluctuations, unavoidable small sample sizes, the presence of interfering nuclides, or other uncontrollable circumstances may render these LLDs unachievable. In such cases, the contributing factors shall be identified and described in the Annual Radiological Environmental Operating Report.

- (4) This LLD applies only to analyses where nuclide-specific separation and counting procedures are required per Table 12.6-1.

12.6 RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

12.6.2 LAND USE CENSUS

REC 12.6.2 A Land Use Census shall be conducted and shall identify within a distance of 8 km (5 miles) the location in each of the 16 meteorological sectors of the nearest livestock, the nearest milk animal (including an enumeration and feed sources), and the nearest residence. The nearest industrial facility shall also be documented if closer than the nearest residence. For dose calculations, a garden will be assumed at the nearest residence in each sector.

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APPLICABILITY: At all times.

ACTIONS

-----NOTE-----

The provisions of REC 12.0.3 and REC 12.0.4 are not applicable.

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|--|--|--|
| <p>A. Land Use Census identifies a location(s) which yields a calculated dose or dose commitment greater than the values currently being calculated in REC 12.4.3.</p> | <p>A.1 Identify the new location(s) in the applicable Radioactive Effluent Release Report.</p> | <p>As part of the Radioactive Effluent Release Report per Units 2/3 TS 5.6.3 and Unit 1 TS 6.9.A.4</p> |
| <p>B. -----NOTE----- Required Action B.1 shall be completed if this condition is entered. ----- Land use census identifies a location which yields a calculated dose or dose commitment (via the same exposure pathway) 20% greater than at a location from which samples are currently being obtained in accordance with REC 12.6.1.</p> | <p>B.1 Add the new location to the Radiological Environmental Monitoring Program. <u>AND</u> B.2 Submit documentation for a change in the ODCM including a revised figure(s) and table(s) for the ODCM reflecting the new location(s) with information supporting the change in sampling locations. The sampling location(s), excluding the control station location, having the lowest calculated dose or dose commitment(s), via the same exposure pathway, may be deleted from the radiological environmental monitoring program after October 31 of the year in which Land Use Census was conducted.</p> | <p>30 days As part of the Radioactive Effluent Release Report per Units 2/3 TS 5.6.3 and Unit 1 TS 6.9.A.4</p> |

12.6.2 SURVEILLANCE REQUIREMENTS

| SURVEILLANCE REQUIREMENT | | FREQUENCY |
|--------------------------|---|---|
| RSR 12.6.2.1 | Conduct a Land Use Census during the growing season by a door-to-door survey, aerial survey, by consulting local agriculture authorities, or by some other appropriate means. | 12 months |
| RSR 12.6.2.2 | Include the results of the Land Use Census in the Annual Radiological Environmental Operating Report. | As part of the Annual Radiological Environmental Operating Report per Units 2/3 TS 5.6.2 and Unit 1 TS 6.9.A.3. |

12.6 RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

12.6.3 INTER-LABORATORY COMPARISON PROGRAM

REC 12.6.3 Analyses shall be performed on radioactive materials supplied as part of an Interlaboratory Comparison Program that correspond to samples required by Table 12.6-1 or a media that is equivalent.

APPLICABILITY: At all times.

ACTIONS

-----NOTE-----

The provisions of REC 12.0.3 and REC 12.0.4 are not applicable.

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|--|---|---|
| A. Requirements of REC 12.6.3 not met. | A.1 Report corrective actions to prevent recurrence to the NRC in the Annual Radiological Environmental Operating Report. | As part of the Annual Radiological Environmental Operating Report per Units 2/3 TS 5.6.2 and Unit 1 TS 6.9.A.3. |

12.6.3 SURVEILLANCE REQUIREMENTS

| SURVEILLANCE REQUIREMENT | FREQUENCY |
|--|---|
| RSR 12.6.3.1 Include a summary of the results of the Interlaboratory Comparison Program in the Annual Radiological Environmental Operating Report. | As part of the Annual Radiological Environmental Operating Report per Units 2/3 TS 5.6.2 and Unit 1 TS 6.9.A.3. |

12.7 METEOROLOGICAL MONITORING PROGRAM (NOT APPLICABLE)

12.8 ON-SITE GROUNDWATER AND STORM SEWER MONITORING

12.8.1 ON-SITE GROUNDWATER AND STORM SEWER MONITORING

REC 12.8.1 On-site groundwater and storm sewers shall be sampled and analyzed for tritium to provide indication of unmonitored or abnormal radioactive releases.

APPLICABILITY: At all times.

ACTIONS

-----NOTE-----

The provisions of REC 12.0.3 and REC 12.0.4 are not applicable.

| CONDITION | REQUIRED ACTION | COMPLETION TIME |
|--|---|--|
| A. Detectable tritium is found in site groundwater <u>OR</u> storm sewers. | A.1 Initiate corrective action in accordance with the site Corrective Action Program. | Immediately. |
| B. Detectable tritium activity is found in the site storm sewers. | B.1 Report the release of activity in the Annual Radioactive Effluent Release Report. | As part of the Radioactive Effluent Release Report per Units 2/3 TS 5.6.3 and Unit 1 TS 6.9.A.4. |

12.8.1 SURVEILLANCE REQUIREMENTS

| SURVEILLANCE REQUIREMENT | FREQUENCY |
|--|------------|
| RSR 12.8.1.1 Perform on-site storm sewer water and groundwater monitoring for tritium at the detection capability of Table 12.6-3. | 12 months. |

12.9 ADMINISTRATIVE REQUIREMENTS

12.9.1 Station Operating Records

Records and/or logs shall be kept in a manner convenient for review and shall be retained per site procedures.

12.9.2 Offsite Dose Calculation Manual (ODCM)

12.9.2.1 The ODCM shall contain the methodology and parameters used in the calculation of offsite doses resulting from radioactive gaseous and liquid effluents, in the calculation of gaseous and liquid effluent monitoring alarm and trip setpoints, and in the conduct of the Radiological Environmental Monitoring Program.

12.9.2.2 The ODCM shall also contain (1) the Radioactive Effluent Controls and Radiological Environmental Monitoring Programs (described in ODCM Sections 12.2 - 12.6) and (2) descriptions of the information that should be included in the Annual Radiological Environmental Operating and Radioactive Effluent Release Reports required by Unit 1 Technical Specification 6.9, Units 2 and 3 Technical Specifications 5.6.2 and 5.6.3, and ODCM Sections 12.9.3 and 12.9.4.

12.9.2.3 Licensee initiated changes to the ODCM:

- 1) Shall be documented and records of reviews performed shall be retained. This documentation shall contain:
 - a. Sufficient information to support the change(s) together with the appropriate analyses or evaluations justifying the change(s), and
 - b. A determination that the change(s) maintain the levels of radioactive effluent control required by 10 CFR 20.1302, 40 CFR 190, 10 CFR 50.36a, and 10 CFR 50, Appendix I, and do not adversely impact the accuracy or reliability of effluent, dose, or setpoint calculations;
- 2) Shall become effective after approval of the station manager; and
- 3) Shall be submitted to the NRC in the form of a complete, legible copy of the entire ODCM as a part of or concurrent with the Radioactive Effluent Release Report for the period of the report in which any change in the ODCM was made. Each change shall be identified by markings in the margin of the affected pages, clearly indicating the area of the page that was changed, and shall indicate the date (i.e., month and year) the change was implemented.

12.9.3 Annual Radiological Environmental Operating Report

-----NOTE-----

A single submittal may be made for a multiple unit station. The submittal should combine sections common to all units at the station.

For Unit 1, Routine Annual Radiological Environmental Operating Reports covering the decommissioning activities of the unit during the previous calendar year shall be submitted in accordance with Section 6.9.A.3 of the Unit 1 Technical Specifications.

For Units 2 and 3, Routine Annual Radiological Environmental Operating Reports covering the operation of the unit during the previous calendar year shall be submitted in accordance with Section 5.6.2 of the Units 2 and 3 Technical Specifications.

The Annual Radiological Environmental Operating Report shall be consistent with the objectives outlined in the Offsite Dose Calculation Manual (ODCM), and in 10 CFR 50, Appendix I, Sections IV.B.2, IV.B.3, and IV.C and shall include:

- 12.9.3.1 Summaries, interpretations, and an analysis of trends of the results of the Radiological Environmental Monitoring Program for the reporting period, including a comparison with previous environmental surveillance reports, and an assessment of the observed impacts of the plant operation on the environment.
- 12.9.3.2 Results of the land use census required by RSR 12.6.2.2.
- 12.9.3.3 Results of analysis of all radiological environmental samples and of all environmental radiation measurements taken during the period pursuant to the locations specified in the tables and figures in Part II, Section 6 of the ODCM, as well as summarized and tabulated results of these analyses and measurements in the format of the table in the Radiological Assessment Branch Technical Position, Revision 1, November 1979. In the event that some individual results are not available for inclusion with the report, the report shall be submitted noting and explaining the reasons for the missing results. The missing data shall be submitted as soon as possible in a supplementary report.
- 12.9.3.4 A summary description of the radiological environmental monitoring program.
- 12.9.3.5 At least two legible maps (one map shall cover stations near the site boundary; a second shall include the more distant stations) covering all sampling locations keyed to a table giving distances and directions from the centerline of the two operating reactors.
- 12.9.3.6 Results of licensee (i.e., contracted vendor) participation Interlaboratory Comparison Program described in Section REC 12.6.3.
- 12.9.3.7 A discussion of all deviations from the sampling schedule of Table 12.6-1.
- 12.9.3.8 A discussion of all analyses in which the LLD required by Table 12.6-3 was not achievable.

12.9.4 Annual Radioactive Effluent Release Report

-----NOTE-----

A single submittal may be made for a multiple unit station. The submittal should combine sections common to all units at the station; however, for units with separate radwaste systems, the submittal shall specify the releases of radioactive material from each unit.

For Unit 1, the Radioactive Effluent Release Reports covering the decommissioning activities of the unit during the previous calendar year shall be submitted in accordance with Section 6.9.A.4 of the Unit 1 Technical Specifications.

For Units 2 and 3, the Radioactive Effluent Release Reports covering the operation of the unit during the previous calendar year shall be submitted in accordance with Section 5.6.3 of the Units 2 and 3 Technical Specifications.

The Annual Radioactive Effluent Release Report shall be consistent with the objectives outlined in the ODCM and Process Control Program (PCP) and in conformance with 10 CFR 50.36a and 10 CFR 50, Appendix I, Section IV.B.1 and shall include:

- 12.9.4.1 A summary of the quantities of radioactive liquid and gaseous effluents and solid waste released from the unit as outlined in Regulatory Guide 1.21, "Measuring, Evaluating, and Reporting Radioactivity in Solid Wastes and Releases of Radioactive Materials in Liquid and Gaseous Effluents for Light-Water-Cooled Nuclear Power Plants," Revision 1, June 1974, with data summarized on a quarterly basis following the format of Appendix B thereof.
- 12.9.4.2 An annual summary of hourly meteorological data collected over the previous year in the form of cumulative joint frequency distributions of wind speed, wind direction, and atmospheric stability for the quarterly periods.
- 12.9.4.3 An assessment of the radiation doses due to the radioactive liquid and gaseous effluents released from the station during the previous calendar year. The meteorological conditions concurrent with the time of release of radioactive materials in gaseous effluents, as determined by sampling frequency and measurement, or approximate or conservative approximate methods (including the use of historical average meteorological data), shall be used for determining the gaseous pathway doses. The assessment of radiation dose shall be performed in accordance with the methodology and parameters in the ODCM.
- 12.9.4.4 An assessment of radiation doses to the likely most exposed MEMBER OF THE PUBLIC from reactor releases and other nearby uranium fuel cycle sources, including doses from primary effluent pathways and direct radiation, for the previous calendar year to show conformance with 40 CFR 190, Environmental Radiation Protection Standards for Nuclear Power Operation.

- 12.9.4.5 The following information for each class of solid waste (as defined by 10 CFR Part 61) shipped offsite during the report period:
- 1) Container volume
 - 2) Total curie content (specify whether determined by measurement or estimate)
 - 3) Principle radionuclides (specify whether determined by measurement or estimate)
 - 4) Source of waste and processing employed (e.g., dewatered spent resin, compacted dry waste, evaporator bottoms).
 - 5) Type of container (e.g., LSA, Type A, Type B, Large Quantity)
 - 6) Solidification agent or absorbent (e.g., cement, urea formaldehyde)
- 12.9.4.6 A list and description of unplanned releases from the site to UNRESTRICTED AREAS of radioactive materials in gaseous and liquid effluents made during the reporting period.
- 12.9.4.7 Significant changes made to the PCP during the reporting period.
- 12.9.4.8 Changes to the ODCM, as well as a listing of new locations for dose calculations and/or environmental monitoring identified by the Land Use Census pursuant to Unit 1 Technical Specification 6.14.A.3 and Units 2 and 3 Technical Specification 5.5.1.
- 12.9.4.9 Major changes to radioactive liquid, gaseous, and solid waste treatment systems as described in Section 12.9.5 if not submitted as part of the annual FSAR update.

12.9.5 Major Changes to Radioactive Liquid, Gaseous, and Solid Waste Treatment Systems

-----NOTE-----

This information may be submitted as part of the annual FSAR update.

12.9.5.1 Licensee initiated major changes to the radioactive waste systems (liquid, gaseous, and solid):

- 1) Shall be reported to the Commission in the Radioactive Effluent Release Report for the period in which the evaluation was reviewed by the Plant Operations Review Committee (PORC). The discussion of each change shall contain:
 - a. A summary of the evaluation that led to the determination that the change could be made in accordance with 10 CFR Part 50.59;
 - b. Sufficient detailed information to totally support the reason for the change without benefit of additional or supplemental information;
 - c. A detailed description of the equipment, components, and process involved and the interfaces with other plant systems;
 - d. An evaluation of the change, which shows the predicted releases of radioactive materials in liquid and gaseous effluents and/or quantity of solid waste that differ from those previously predicted in the license application and amendments thereto;
 - e. An evaluation of the change, which shows the expected maximum exposures to individual in the UNRESTRICTED AREA and to the general population that differ from those previously predicted in the license application and amendments thereto;
 - f. A comparison of the predicted releases of radioactive materials, in liquid and gaseous effluents and in solid waste, to the actual releases for the period in which the changes were made;
 - g. An estimate of the exposure to plant operating personnel as a result of the change; and
 - h. Documentation of the fact that the change was reviewed and found acceptable by the PORC.
- 2) Shall become effective upon review and acceptance by the PORC.

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B 1.0 BASES

General

The BASES contained in the succeeding pages summarize the reasons for the RECs but are not part of these RECs.

It is expected that releases of radioactive material in effluents will be kept at small fractions of the limits specified in Section 20.1302 of 10 CFR, Part 20. At the same time, the licensee is permitted the flexibility of operation, compatible with consideration of health and safety, to assure that the public is provided a dependable source of power even under unusual operating conditions which may temporarily result in releases higher than such small fractions, but still within the limits specified in Section 20.1302 of 10 CFR, Part 20. It is expected that in using this operational flexibility under unusual operating conditions the licensee will exert his best efforts to keep levels of radioactive material in effluents as low as practicable.

B 12.0 OFFSITE DOSE CALCULATION MANUAL (ODCM) RADIOLOGICAL EFFLUENT CONTROL (REC) APPLICABILITY

BASES

RECs REC 12.0.1 through REC 12.0.6 establish the general requirements applicable to all RECs in Sections 12.1 through 12.8 and apply at all times, unless otherwise stated.

REC 12.0.1 REC 12.0.1 establishes the Applicability statement within each individual REC as the requirement for when the REC is required to be met (i.e., when the unit is in the MODES or other specified conditions of the Applicability statement of each REC).

REC 12.0.2 REC 12.0.2 establishes that upon discovery of a failure to meet a REC, the associated ACTIONS shall be met. The Completion Time of each Required Action for an ACTIONS Condition is applicable from the point in time that an ACTIONS Condition is entered. The Required Actions establish those remedial measures that must be taken within specified Completion Times when the requirements of a REC are not met. This REC establishes that:

- a. Completion of the Required Actions within the specified Completion Times constitutes compliance with a REC; and
- b. Completion of the Required Actions is not required when a REC is met within the specified Completion Time, unless otherwise specified.

There are two basic types of Required Actions. The first type of Required Action specifies a time limit in which the REC must be met. This time limit is the Completion Time to restore a non-functional system or component to FUNCTIONAL status or to restore variables to within specified limits. If this type of Required Action is not completed within the specified Completion Time, a shutdown may be required to place the unit in a MODE or condition in which the REC is not applicable. (Whether stated as a Required Action or not, correction of the entered Condition is an action that may always be considered upon entering ACTIONS.) The second type of Required Action specifies the remedial measures that permit continued operation of the unit that is not further restricted by the Completion Time. In this case, compliance with the Required Actions provides an acceptable level of safety for continued operation.

Completing the Required Actions is not required when a REC is met or is no longer applicable, unless otherwise stated in the individual RECs.

(continued)

BASES

REC 12.0.2
(continued)

The nature of some Required Actions of some Conditions necessitates that, once the Condition is entered, the Required Actions must be completed even though the associated Condition no longer exists. The individual REC's ACTIONS specify the Required Actions where this is the case. An example of this is in REC 12.3.1, Liquid Effluent Concentration.

The Completion Times of the Required Actions are also applicable when a system or component is removed from service intentionally. The reasons for intentionally relying on the ACTIONS include, but are not limited to, performance of Surveillances, preventive maintenance, corrective maintenance, or investigation of operational problems. Entering ACTIONS for these reasons must be done in a manner that does not compromise safety. Intentional entry into ACTIONS should not be made for operational convenience. Additionally, if intentional entry into ACTIONS would result in redundant equipment being non-functional, alternatives should be used instead. Doing so limits the time both subsystems/divisions of a function are non-functional and limits the time conditions exist which may result in REC 12.0.3 being entered. Individual RECs may specify a time limit for performing a RSR when equipment is removed from service or bypassed for testing. In this case, the Completion Times of the Required Actions are applicable when this time limit expires, if the equipment remains removed from service or bypassed.

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When a change in MODE or other specified condition is required to comply with Required Actions, the unit may enter a MODE or other specified condition in which another REC becomes applicable. In this case, the Completion Times of the associated Required Actions would apply from the point in time that the new REC becomes applicable and the ACTIONS Condition(s) are entered.

REC 12.0.3

REC 12.0.3 establishes the actions that must be implemented when a REC is not met and:

- a. An associated Required Action and Completion Time is not met and no other Condition applies; or
- b. The condition of the unit is not specifically addressed by the associated ACTIONS. This means that no combination of Conditions stated in the ACTIONS can be made that exactly corresponds to the actual condition of the unit. Sometimes, possible combinations of Conditions are such that entering REC 12.0.3 is warranted; in such cases, the ACTIONS specifically state a Condition corresponding to such combinations and also that REC 12.0.3 be entered immediately.

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BASES

**REC 12.0.3
(continued)**

Upon entering REC 12.0.3, 1 hour is allowed to initiate actions to implement appropriate compensatory actions and verify the plant is not in an unanalyzed condition or that a required safety function is not compromised. Within 12 hours, Station Duty Officer approval of the compensatory actions and the plan for exiting REC 12.0.3 must be obtained. The use and interpretation of specified times to complete the actions of REC 12.0.3 are consistent with the discussion of Section 1.3, Completion Times.

The actions required in accordance with REC 12.0.3 may be terminated and REC 12.0.3 exited if any of the following occurs:

- a. The REC is now met.
- b. A Condition exists for which the Required Actions have now been performed.
- c. ACTIONS exist that do not have expired Completion Times. These Completion Times are applicable from the point in time that the Condition is initially entered and not from the time REC 12.0.3 is exited.

In MODES 1, 2, and 3, REC 12.0.3 provides actions for Conditions not covered in other Requirements. The requirements of REC 12.0.3 do not apply in MODES 4 and 5 because the unit is already in the most restrictive Condition. The requirements of REC 12.0.3 do not apply in other specified conditions of the Applicability (unless in MODE 1, 2, or 3) because the ACTIONS of individual RECs sufficiently define the remedial measures to be taken.

REC 12.0.4

REC 12.0.4 establishes limitations on changes in MODES or other specified conditions in the Applicability when a REC is not met. It allows placing the unit in a MODE or other specified condition stated in that Applicability (e.g., Applicability desired to be entered) when unit conditions are such that the requirements of the REC would not be met, in accordance with REC 12.0.4.a, REC 12.0.4.b, and REC 12.0.4.c.

REC 12.0.4.a allows entry into a MODE or other specified condition in the Applicability with the REC not met when the associated ACTIONS to be entered permit continued operation in the MODE or other specified condition in the Applicability for an unlimited period of time. Compliance with Required Actions that permit continued operation of the unit for an unlimited period of time in a MODE or other specified condition provides an acceptable level of safety for continued operation. This is without regard to the status of the unit before or after the MODE change. Therefore, in such cases, entry into a MODE or other specified condition in the Applicability may be made in accordance with the provisions of the Required Actions.

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BASES

REC 12.0.4
(continued)

REC 12.0.4.b allows entry into a MODE or other specified condition in the Applicability with the REC not met after performance of a risk assessment addressing non-functional systems and components, consideration of the results, determination of the acceptability of entering the MODE or other specified condition in the Applicability, and establishment of risk management actions, if appropriate.

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The risk assessment may use quantitative, qualitative, or blended approaches, and the risk assessment will be conducted using the plant program, procedures, and criteria in place to implement 10 CFR 50.65(a)(4), which requires that risk impacts of maintenance activities be assessed and managed. The risk assessment, for the purposes of REC 12.0.4.b, must take into account all non-functional Technical Specification equipment regardless of whether the equipment is included in the normal 10 CFR 50.65(a)(4) risk assessment scope. The risk assessments will be conducted using the procedures and guidance endorsed by Regulatory Guide 1.182, "Assessing and Managing Risk Before Maintenance Activities at Nuclear Power Plants." Regulatory Guide 1.182 endorses the guidance in Section 11 of NUMARC 93-01, "Industry Guideline for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants." These documents address general guidance for conduct of the risk assessment, quantitative and qualitative guidelines for establishing risk management actions, and example risk management actions. These include actions to plan and conduct other activities in a manner that controls overall risk, increased risk awareness by shift and management personnel, actions to reduce the duration of the condition, actions to minimize the magnitude of risk increases (establishment of backup success paths or compensatory measures), and determination that the proposed MODE change is acceptable. Consideration should also be given to the probability of completing restoration such that the requirements of the REC would be met prior to the expiration of ACTIONS Completion Times that would require exiting the Applicability.

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REC 12.0.4.b may be used with single, or multiple systems and components unavailable. NUMARC 93-01 provides guidance relative to consideration of simultaneous unavailability of multiple systems and components.

The results of the risk assessment shall be considered in determining the acceptability of entering the MODE or other specified condition in the Applicability, and any corresponding risk management actions. The REC 12.0.4.b risk assessments do not have to be documented.

(continued)

BASES

REC 12.0.4
(continued)

The ODCM allows continued operation with equipment unavailable in MODE 1 for the duration of the Completion Time. Since this is allowable, and since in general the risk impact in that particular MODE bounds the risk of transitioning into and through the applicable MODES or other specified conditions in the Applicability of the REC, the use of the REC 12.0.4.b allowance should be generally acceptable, as long as the risk is assessed and managed as stated above.

REC 12.0.4.c allows entry into a MODE or other specified condition in the Applicability with the REC not met based on a Note in the Specification which states REC 12.0.4.c is applicable. These specific allowances permit entry into MODES or other specified conditions in the Applicability when the associated ACTIONS to be entered do not provide for continued operation for an unlimited period of time and a risk assessment has not been performed. This allowance may apply to all the ACTIONS or to a specific Required Action of a REC. The risk assessments performed to justify the use of REC 12.0.4.b usually only consider systems and components. For this reason, REC 12.0.4.c is typically applied to RECs which describe values and parameters.

The provisions of this REC should not be interpreted as endorsing the failure to exercise the good practice of restoring systems or components to FUNCTIONAL status before entering an associated MODE or other specified condition in the Applicability.

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The provisions of REC 12.0.4 shall not prevent changes in MODES or other specified conditions in the Applicability that are required to comply with ACTIONS. In addition, the provisions of REC 12.0.4 shall not prevent changes in MODES or other specified conditions in the Applicability that result from any unit shutdown. In this context, a unit shutdown is defined as a change in MODE or other specified condition in the Applicability associated with transitioning from MODE 1 to MODE 2, MODE 2 to MODE 3, and MODE 3 to MODE 4.

Upon entry into a MODE or other specified condition in the Applicability with the REC not met, REC 12.0.1 and REC 12.0.2 require entry into the applicable conditions and Required Actions until the Condition is resolved, until the REC is met, or until the unit is not within the Applicability of the REC.

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BASES

REC 12.0.4
(continued)

Surveillances do not have to be performed on the associated non-functional equipment (or on variables outside the specified limits), as permitted by RSR 12.0.1. Therefore, utilizing REC 12.0.4 is not a violation of RSR 12.0.1 or RSR 12.0.4 for any Surveillances that have not been performed on non-functional equipment. However, RSRs must be met to ensure FUNCTIONALITY prior to declaring the associated equipment FUNCTIONAL (or variable within limits) and restoring compliance with the affected REC.

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REC 12.0.5

REC 12.0.5 establishes the allowance for restoring equipment to service under administrative controls when it has been removed from service or declared non-functional to comply with ACTIONS. The sole purpose of this Requirement is to provide an exception to REC 12.0.2 (e.g., to not comply with the applicable Required Action(s)) to allow the performance of required testing to demonstrate:

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- a. The FUNCTIONALITY of the equipment being returned to service;
or
- b. The FUNCTIONALITY of other equipment.

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The administrative controls ensure the time the equipment is returned to service in conflict with the requirements of the ACTIONS is limited to the time absolutely necessary to perform the required testing to demonstrate FUNCTIONALITY. This REC does not provide time to perform any other preventive or corrective maintenance.

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An example of demonstrating the FUNCTIONALITY of the equipment being returned to service is reopening a containment isolation valve that has been closed to comply with Required Actions, and must be reopened to perform the required testing.

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An example of demonstrating the FUNCTIONALITY of other equipment is taking a non-functional channel or trip system out of the tripped condition to prevent the trip function from occurring during the performance of required testing on another channel in the other trip system. A similar example of demonstrating the FUNCTIONALITY of other equipment is taking a non-functional channel or trip system out of the tripped condition to permit the logic to function and indicate the appropriate response during the performance of required testing on another channel in the same trip system.

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BASES

REC 12.0.6 REC 12.0.6 establishes the applicability of each REC to Unit 1, Unit 2, and Unit 3 operation. Whenever a requirement applies to only one unit, or is different for each unit, this will be identified in the appropriate section of the REC (e.g., Applicability, RSR, etc.) with parenthetical reference, Notes, or other appropriate presentation within the body of the requirement.

B 12.0 RADIOLOGICAL EFFLUENT SURVEILLANCE REQUIREMENT (RSR) APPLICABILITY

BASES

RSRs RSR 12.0.1 through RSR 12.0.5 establish the general requirements applicable to all Requirements in 12.1 through 12.8 and apply at all times, unless otherwise stated.

RSR 12.0.1 RSR 12.0.1 establishes the requirement that RSRs must be met during the MODES or other specified conditions in the Applicability for which the requirements of the REC apply, unless otherwise specified in the individual RSRs. This RSR is to ensure that Surveillances are performed to verify the FUNCTIONALITY of systems and components, and that variables are within specified limits. Failure to meet a Surveillance within the specified Frequency, in accordance with RSR 12.0.2, constitutes a failure to meet a REC.

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Systems and components are assumed to be FUNCTIONAL when the associated RSRs have been met. Nothing in this RSR, however, is to be construed as implying that systems or components are FUNCTIONAL when:

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- a. The systems or components are known to be non-functional, although still meeting the RSRs; or
- b. The requirements of the Surveillance(s) are known to be not met between required Surveillance performances.

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Surveillances do not have to be performed when the unit is in a MODE or other specified condition for which the requirements of the associated REC are not applicable, unless otherwise specified.

Unplanned events may satisfy the requirements (including applicable acceptance criteria) for a given RSR. In this case, the unplanned event may be credited as fulfilling the performance of the RSR.

Surveillances, including Surveillances invoked by Required Actions, do not have to be performed on non-functional equipment because the ACTIONS define the remedial measures that apply. Surveillances have to be met and performed in accordance with RSR 12.0.2, prior to returning equipment to FUNCTIONAL status.

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(continued)

BASES

RSR 12.0.1
(continued)

Upon completion of maintenance, appropriate post maintenance testing is required to declare equipment FUNCTIONAL. This includes ensuring applicable Surveillances are not failed and their most recent performance is in accordance with RSR 12.0.2. Post maintenance testing may not be possible in the current MODE or other specified conditions in the Applicability due to the necessary unit parameters not having been established. In these situations, the equipment may be considered FUNCTIONAL provided testing has been satisfactorily completed to the extent possible and the equipment is not otherwise believed to be incapable of performing its function. This will allow operation to proceed to a MODE or other specified condition where other necessary post maintenance tests can be completed.

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RSR 12.0.2

RSR 12.0.2 establishes the requirements for meeting the specified Frequency for Surveillances and any Required Action with a Completion Time that requires the periodic performance of the Required Action on a "once per..." interval.

RSR 12.0.2 permits a 25% extension of the interval specified in the Frequency. This extension facilitates Surveillance scheduling and considers plant operating conditions that may not be suitable for conducting the Surveillance (e.g., transient conditions or other ongoing Surveillance or maintenance activities).

The 25% extension does not significantly degrade the reliability that results from performing the Surveillance at its specified Frequency. This is based on the recognition that the most probable result of any particular Surveillance being performed is the verification of conformance with the RSRs. The exceptions to RSR 12.0.2 are those Surveillances for which the 25% extension of the interval specified in the Frequency does not apply. These exceptions are stated in the individual RECs. The requirements of regulations and the Technical Specifications (TS) take precedence over the ODCM. Therefore, when a test interval is specified in the regulations or TS, the test interval cannot be extended by the ODCM, and the RSR includes a Note in the Frequency stating "RSR 12.0.2 is not applicable."

As stated in RSR 12.0.2, the 25% extension also does not apply to the initial portion of a periodic Completion Time that requires performance on a "once per..." basis. The 25% extension applies to each performance after the initial performance. The initial performance of the Required Action, whether it is a particular Surveillance or some other remedial action, is considered a single action with a single Completion Time. One reason for not allowing the 25% extension to this Completion Time is that such an action usually verifies that no loss of function has occurred by checking the status of redundant or diverse components or accomplishes the function of the non-functional equipment in an alternative manner.

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(continued)

BASES

RSR 12.0.2
(continued)

The provisions of RSR 12.0.2 are not intended to be used repeatedly merely as an operational convenience to extend Surveillance intervals (other than those consistent with refueling intervals) or periodic Completion Time intervals beyond those specified.

RSR 12.0.3

RSR 12.0.3 establishes the flexibility to defer declaring affected equipment non-functional or an affected variable outside the specified limits when a Surveillance has not been completed within the specified Frequency. A delay period of up to 24 hours or up to the limit of the specified Frequency, whichever is greater, applies from the point in time that it is discovered that the Surveillance has not been performed in accordance with RSR 12.0.2, and not at the time that the specified Frequency was not met. This delay period provides adequate time to complete Surveillances that have been missed. This delay period permits the completion of a Surveillance before complying with Required Actions or other remedial measures that might preclude completion of the Surveillance.

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The basis for this delay period includes consideration of unit conditions, adequate planning, availability of personnel, the time required to perform the Surveillance, the safety significance of the delay in completing the required Surveillance, and the recognition that the most probable result of any particular Surveillance being performed is the verification of conformance with the requirements.

When a Surveillance with a Frequency based not on time intervals, but upon specified unit conditions, operating situations, or requirements of regulations (e.g., prior to each release) is discovered to not have been performed when specified, RSR 12.0.3 allows for the full delay period of up to the specified Frequency to perform the Surveillance. However, since there is not a time interval specified, the missed Surveillance should be performed at the first reasonable opportunity.

RSR 12.0.3 provides a time limit for, and allowances for the performance of, Surveillances that become applicable as a consequence of MODE changes imposed by Required Actions.

Failure to comply with specified Frequencies for RSRs is expected to be an infrequent occurrence. Use of the delay period established by RSR 12.0.3 is a flexibility which is not intended to be used as an operational convenience to extend Surveillance intervals. While up to 24 hours or the limit of the specified Frequency is provided to perform the missed Surveillance, it is expected that the missed Surveillance will be performed at the first reasonable opportunity. The determination of the first reasonable opportunity should include consideration of the impact on plant risk (from delaying the Surveillance as well as any plant configuration changes required or shutting the plant down to perform the Surveillance) and impact on any analysis assumptions, in addition to unit conditions, planning, availability of personnel, and the time required

(continued)

BASES

RSR 12.0.3
(continued)

to perform the Surveillance. This risk impact should be managed through the program in place to implement 10 CFR 50.65(a)(4) and its implementation guidance, NRC Regulatory Guide 1.182, "Assessing and Managing Risk Before Maintenance Activities at Nuclear Power Plants." This Regulatory Guide addresses consideration of temporary and aggregate risk impacts, determination of risk management action thresholds, and risk management action up to and including plant shutdown. The missed Surveillance should be treated as an emergent condition as discussed in the Regulatory Guide. The risk evaluation may use quantitative, qualitative, or blended methods. The degree of depth and rigor of the evaluation should be commensurate with the importance of the component. Missed Surveillances for important components should be analyzed quantitatively. If the results of the risk evaluation determine the risk increase is significant, this evaluation should be used to determine the safest course of action. All missed Surveillances will be placed in the station's Corrective Action Program.

If a Surveillance is not completed within the allowed delay period, then the equipment is considered non-functional or the variable then is considered outside the specified limits and the Completion Times of the Required Actions for the applicable REC Conditions begin immediately upon expiration of the delay period. If a Surveillance is failed within the delay period, then the equipment is non-functional, or the variable is outside the specified limits and the Completion Times of the Required Actions for the applicable REC Conditions begin immediately upon the failure of the Surveillance.

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Completion of the Surveillance within the delay period allowed by this RSR, or within the Completion Time of the ACTIONS, restores compliance with RSR 12.0.1.

RSR 12.0.4

RSR 12.0.4 establishes the requirement that all applicable RSRs must be met before entry into a MODE or other specified condition in the Applicability.

This RSR ensures that system and component FUNCTIONALITY requirements and variable limits are met before entry into MODES or other specified conditions in the Applicability for which these systems and components ensure safe operation of the unit. The provisions of this RSR should not be interpreted as endorsing the failure to exercise the good practice of restoring systems or components to FUNCTIONAL status before entering an associated MODE or other specified condition in the Applicability.

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A provision is included to allow entry into a MODE or other specified condition in the Applicability when a REC is not met due to Surveillance not being met in accordance with REC 12.0.4.

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BASES

RSR 12.0.4
(continued)

However, in certain circumstances, failing to meet a RSR will not result in RSR 12.0.4 restricting a MODE change or other specified condition change. When a system, subsystem, division, component, device, or variable is non-functional or outside its specified limits, the associated RSR(s) are not required to be performed, per RSR 12.0.1, which states that surveillances do not have to be performed on non-functional equipment. When equipment is non-functional, RSR 12.0.4 does not apply to the associated RSR(s) since the requirement for the RSR(s) to be performed is removed. Therefore, failing to perform the RSRs within the specified Frequency does not result in a RSR 12.0.4 restriction to changing MODES or other specified conditions of the Applicability. However, since the REC is not met in this instance, REC 12.0.4 will govern any restrictions that may (or may not) apply to MODE or other specified condition changes. RSR 12.0.4 does not restrict changing MODES or other specified conditions of the Applicability when a Surveillance has not been performed within the specified Frequency, provided the requirement to declare the REC not met has been delayed in accordance with RSR 12.0.3.

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The provisions of RSR 12.0.4 shall not prevent entry into MODES or other specified conditions in the Applicability that are required to comply with ACTIONS. In addition, the provisions of RSR 12.0.4 shall not prevent changes in MODES or other specified conditions in the Applicability that result from any unit shutdown. In this context, a unit shutdown is defined as a change in MODE or other specified condition in the Applicability associated with transitioning from MODE 1 to MODE 2, MODE 2 to MODE 3, and MODE 3 to MODE 4.

The precise requirements for performance of RSRs are specified such that exceptions to RSR 12.0.4 are not necessary. The specific time frames and conditions necessary for meeting the RSRs are specified in the Frequency, in the Surveillance, or both. This allows performance of Surveillances when the prerequisite condition(s) specified in a Surveillance procedure require entry into the MODE or other specified condition in the Applicability of the associated REC prior to the performance or completion of a Surveillance. A Surveillance that could not be performed until after entering the REC's Applicability would have its Frequency specified such that it is not "due" until the specific conditions needed are met. Alternately, the RSR may be stated in the form of a Note, as not required (to be met or performed) until a particular event, condition, or time has been reached. Further discussion of the specific formats of RSRs' annotation is found in Section 1.4, Frequency.

RSR 12.0.5

RSR 12.0.5 establishes the applicability of each RSR to Unit 1, Unit 2 and Unit 3 operation. Whenever a requirement applies to only one unit, or is different for each unit, this will be identified with parenthetical reference, Notes, or other appropriate presentation within the RSR.

B 12.1 NOT USED

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B 12.2 INSTRUMENTATION

B 12.2.1 Radioactive Liquid Effluent Monitoring Instrumentation

BASES

The radioactive liquid effluent monitoring instrumentation is provided to monitor and control, as applicable, the releases of radioactive materials in liquid effluents during actual or potential releases of liquid effluents. The Alarm/Trip Setpoints for these instruments shall be calculated in accordance with the methodology and parameters in the ODCM to ensure that the alarm/trip will occur prior to exceeding the limits of 10 CFR Part 20 and the limits of the RECs. The FUNCTIONALITY and use of this instrumentation is consistent with the requirements of General Design Criteria 60, 63, and 64 of Appendix A to 10 CFR Part 50.

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REC 12.2.1 implements Technical Specification 5.5.4.a for liquid effluent monitoring instrumentation.

B 12.2 INSTRUMENTATION

B 12.2.2 Radioactive Gaseous Effluent Monitoring Instrumentation

BASES

The radioactive gaseous effluent monitoring instrumentation is provided to monitor and control, as applicable, the releases of radioactive materials in gaseous effluents during actual or potential releases of gaseous effluents. The Alarm/Trip Setpoints for these instruments shall be calculated and adjusted in accordance with the methodology and parameters in the ODCM to ensure that the alarm/trip will occur prior to exceeding the limits of 10 CFR Part 20 and the limits of the RECs. The FUNCTIONALITY and use of this instrumentation is consistent with the requirements of General Design Criteria 60, 63, and 64 of Appendix A to 10 CFR Part 50.

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REC 12.2.2 implements Technical Specification 5.5.4.a for gaseous effluent monitoring instrumentation.

B 12.3 LIQUID EFFLUENTS

B 12.3.1 Liquid Effluent Concentration

BASES

REC 12.3.1 is provided to ensure that the concentration of radioactive materials released in liquid waste effluents to UNRESTRICTED AREAS will be less than ten (10) times the concentration levels specified in Appendix B, Table 2, Column 2 to 10 CFR Part 20. This instantaneous limitation provides additional assurance that the levels of radioactive materials in bodies of water in UNRESTRICTED AREAS will result in exposure within: (1) the Section II.A design objectives of Appendix I, 10 CFR 50, to a MEMBER OF THE PUBLIC, and (2) the limits of 10 CFR 20.1301 to the population. The concentration limits for dissolved or entrained noble gases is based upon the assumption that Xe-135 is the controlling isotope and its MPC in air (submersion) was converted to an equivalent concentration in water using the methods described in International Commission on Radiological Protection (ICRP) Publication 2.

REC 12.3.1 applies to the release of radioactive material in liquid effluents from the site at all times.

The required detection capabilities for radioactive materials in liquid waste samples are tabulated in terms of the lower limits of detection (LLDs). Detailed discussion of the LLD, and other detection limits can be found in Currie, L. A., "Lower Limit of Detection: Definition and Elaboration of a Proposed Position for Radiological Effluent and Environmental Measurements," NUREG/CR-4007 (September 1984), and in the HASL Procedures Manual, HASL-300.

In addition, this limit is associated with 40 CFR Part 141 with regard to concentration limits at the nearest downstream community water supply. The results of the analyses of RSR 12.3.1.1, 12.3.1.2, and 12.3.1.3 shall be used with the calculational methods in the ODCM to assure that the concentrations at the point of release are maintained within the limits of this REC.

The limits of REC 12.3.1 are derived from 10 CFR Part 20.

REC 12.3.1 implements Technical Specification 5.5.4.b. and 5.5.4.c for liquid effluents.

B.12.3 LIQUID EFFLUENTS

B 12.3.2 Dose from Liquid Effluents

BASES

REC 12.3.2 is provided to implement the requirements of Sections II.A, III.A and IV.A of Appendix I, 10 CFR Part 50. The REC implements the guides set forth in Section II.A of Appendix I. The ACTION statements provide the required operating flexibility and at the same time implement the guides set forth in Section IV.A of Appendix I to assure that the releases of radioactive material in liquid effluents will be kept "as low as is reasonably achievable." Also, for fresh water sites with drinking water supplies which can be potentially affected by plant operations, there is reasonable assurance that the operation of the facility will not result in radionuclide concentrations in the finished drinking water that are in excess of the requirements of 40 CFR Part 141. The dose calculation methodology and parameters in the ODCM implement the requirements in Section III.A of Appendix I that conformance with the guides of Appendix I be shown by calculational procedures based on models and data, such that the actual exposure of a MEMBER OF THE PUBLIC through appropriate pathways is unlikely to be substantially underestimated. The equations specified in the ODCM for calculating the doses due to the actual release rates of radioactive materials in liquid effluents are consistent with the methodology provided in Regulatory Guide 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," Revision 1, October 1977 and Regulatory Guide 1.113, "Estimating Aquatic Dispersion of Effluents from Accidental and Routine Reactor Releases for the Purpose of Implementing Appendix I," April 1977. NUREG-0133, "Preparation of Radiological Effluent Technical Specifications for Nuclear Power Plants," October 1978 provides methods for dose calculations consistent with Regulatory Guides 1.109 and 1.113.

REC 12.3.2.1 applies to the release of radioactive materials in liquid effluents from each unit at the site. For units with shared Radwaste Systems, the liquid effluents from the shared systems are to be proportioned among the units sharing that system.

REC 12.3.2.2 applies to the release of radioactive materials in liquid effluents from the station.

The limits of REC 12.3.2.1 are derived from 10 CFR Part 50 Appendix I.

REC 12.3.2.1 implements Technical Specification 5.5.4.d and 5.5.4.e for liquid effluents.

B 12.3 LIQUID EFFLUENTS

B 12.3.3 Liquid Radwaste Treatment Systems

BASES

The FUNCTIONALITY of the Liquid Radwaste Treatment System ensures that this system will be available for use whenever liquid effluents require treatment prior to release to the environment. The requirement that the appropriate portions of this system be used when specified provides assurance that the releases of radioactive materials in liquid effluents will be kept "as low as is reasonably achievable." This control implements the requirements of 10 CFR Part 50.36a, General Design Criterion 60 of Appendix A to 10 CFR Part 50 and the design objective given in Section II.D of Appendix I to 10 CFR Part 50. The specified limits governing the use of appropriate portions of the Liquid Radwaste Treatment System were specified as a suitable fraction of the dose design objectives set forth in Section II.A of Appendix I, 10 CFR Part 50 for liquid effluents.

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REC 12.3.3 applies to the release of radioactive materials in liquid effluents from each unit at the site. For units with shared Radwaste Systems, the liquid effluents from the shared system are to be proportioned among the units sharing that system.

For the purposes of this REC, the Liquid Radwaste Treatment System is any equipment designed and installed to reduce radioactive liquid effluents and can include permanent or portable treatment equipment. Further information on the Liquid Radwaste Systems is contained in section II-2.1.1.

REC 12.3.3 implements Technical Specification 5.5.4.f for liquid effluent treatment systems.

B 12.4 GASEOUS EFFLUENTS

B 12.4.1 Gaseous Effluent Dose Rates

BASES

REC 12.4.1 is provided to ensure that the dose at any time at and beyond the SITE BOUNDARY from gaseous effluents from all units on the site will be within the annual dose limits of 10 CFR Part 20 to UNRESTRICTED AREAS. The annual dose limits are the doses associated with the concentrations of 10 CFR Part 20, Appendix B, Table 2, Column 1. These limits provide reasonable assurance that radioactive material discharged in gaseous effluents will not result in the exposure of a MEMBER OF THE PUBLIC in an unrestricted area, either within or outside the SITE BOUNDARY, to annual average concentrations exceeding the limits specified in Appendix B, Table 2 of 10 CFR Part 20 (10 CFR 20.1301). For MEMBERS OF THE PUBLIC who may at times be within the SITE BOUNDARY, the occupancy of the MEMBER OF THE PUBLIC will usually be sufficiently low to compensate for any increase in the atmospheric diffusion factor above that for the SITE BOUNDARY. Examples of calculations for such MEMBERS OF THE PUBLIC, with appropriate occupancy factors, shall be given in the ODCM. The specified release rate limits restrict, at all times, the corresponding gamma and beta dose rates above background to a MEMBER OF THE PUBLIC at or beyond the SITE BOUNDARY to less than or equal to 500 mrem/year to the total body or to less than or equal to 3000 mrem/year to the skin. These release rate limits also restrict, at all times, the corresponding thyroid dose rate above background to a child via the inhalation pathway to less than or equal to a dose rate of 1500 mrem/year.

REC 12.4.1 applies to the release of radioactive materials in gaseous effluents from all units at the site.

The required detection capabilities for radioactive materials in liquid waste samples are tabulated in terms of the lower limits of detection (LLDs). Detailed discussion of the LLD, and other detection limits can be found in Currie, L. A., "Lower Limit of Detection: Definition and Elaboration of a Proposed Position for Radiological Effluent and Environmental Measurements," NUREG/CR-4007 (September 1984), and in the HASL Procedures Manual, HASL-300.

For purposes of calculating doses resulting from airborne releases, the Unit 1 Main Chimney and the Units 2/3 Main Chimney are considered to be elevated release points, and the Unit 1 Chemical Cleaning Building Stack and the Units 2/3 Reactor Building Ventilation Stack are considered to be mixed mode release points.

REC 12.4.1 implements Technical Specification 5.5.4.c for gaseous effluents and 5.5.4.g.

B 12.4 GASEOUS EFFLUENTS

B 12.4.2 Dose from Noble Gases

BASES

REC 12.4.2 is provided to implement the requirements of Sections II.B, III.A and IV.A of Appendix I, 10 CFR Part 50. The REC implements the guides set forth in Section II.B of Appendix I. The ACTION statements provide the required operating flexibility and at the same time implement the guides set forth in Section IV.A of Appendix I to assure that the releases of radioactive material in gaseous effluents to UNRESTRICTED AREAS will be kept "as low as is reasonably achievable." The Surveillance Requirements implement the requirements in Section III.A of Appendix I that conformance with the guides of Appendix I be shown by calculational procedures based on models and data such that the actual exposure of a MEMBER OF THE PUBLIC through appropriate pathways is unlikely to be substantially underestimated. The dose calculation methodology and parameters established in the ODCM for calculating the doses due to the actual release rates of radioactive noble gases in gaseous effluents are consistent with the methodology provided in Regulatory Guide 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I, "Revision 1, October 1977 and Regulatory Guide 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water Cooled Reactors," Revision 1, July 1977. NUREG-0133, "Preparation of Radiological Effluent Technical Specifications for Nuclear Power Plants," October 1978 provides methods for dose calculations consistent with Regulatory Guides 1.109 and 1.111. The ODCM equations provided for determining the air doses at and beyond the SITE BOUNDARY are based upon the historical average atmospheric conditions.

REC 12.4.2 applies to the release of radioactive materials in gaseous effluents from each unit at the site. For units with shared Radwaste Treatment Systems, the gaseous effluents from the shared system are proportioned among the units sharing that system.

The limits of REC 12.4.2 are derived from 10 CFR Part 50 Appendix I.

REC 12.4.2 implements Technical Specification 5.5.4.e for radioactive noble gas effluents and 5.5.4.h.

B 12.4 GASEOUS EFFLUENTS

B 12.4.3 Dose from Iodine-131, Iodine-133, Tritium, and Radioactive Materials in Particulate Form

BASES

REC 12.4.3 is provided to implement the requirements of Sections II.C, III.A and IV.A of Appendix I, 10 CFR Part 50. The controls are the guides set forth in Section II.C of Appendix I. The ACTION statements provide the required operating flexibility and at the same time implement the guides set forth in Section IV.A of Appendix I to assure that the releases of radioactive materials in gaseous effluents to UNRESTRICTED AREAS will be kept "as low as is reasonably achievable." The ODCM calculational methods specified in the Surveillance Requirements implement the requirements in Section III.A of Appendix I that conformance with the guides of Appendix I be shown by calculational procedures based on models and data such that the actual exposure of a MEMBER OF THE PUBLIC through appropriate pathways is unlikely to be substantially underestimated. The ODCM calculational methodology and parameters for calculating the doses due to the actual release rates of the subject materials are consistent with the methodology provided in Regulatory Guide 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," Revision 1, October 1977 and Regulatory Guide 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors," Revision 1, July 1977. NUREG-0133, "Preparation of Radiological Effluent Technical Specifications for Nuclear Power Plants," October 1978 provides methods for dose calculations consistent with Regulatory Guides 1.109 and 1.111. These equations also provide for determining the actual doses based upon the historical average atmospheric conditions. The release rate controls for I-131, I-133, tritium, and radionuclides in particulate form with half-lives greater than 8 days are dependent upon the existing radionuclide pathways to man in the areas at or beyond the SITE BOUNDARY. The pathways which were examined in the development of these calculations were: 1) individual inhalation of airborne radionuclides, 2) deposition of radionuclides onto green leafy vegetation with subsequent consumption by man, 3) deposition onto grassy areas where milk animals and meat producing animals graze with consumption of the milk and meat by man, and 4) deposition on the ground with subsequent exposure of man.

REC 12.4.3 applies to the release of radioactive materials in gaseous effluents from each unit at the site. For units with shared Radwaste Treatment Systems, the gaseous effluents from the shared system are proportioned among the units sharing that system.

The limits of REC 12.4.3 are derived from 10 CFR Part 50 Appendix I.

REC 12.4.3 implements Technical Specification 5.5.4.e for I-131, I-133, H-3, and radioactive material in particulate form in gaseous effluents and 5.5.4.i.

B 12.4 GASEOUS EFFLUENTS

B 12.4.4 Gaseous Radwaste Treatment System

BASES

The FUNCTIONALITY of the GASEOUS RADWASTE TREATMENT SYSTEM, which reduces the amounts or concentrations of radioactive materials, ensures that the system will be available for use whenever gaseous effluents require treatment prior to release to the environment. The requirement that the appropriate portions of these systems be used, when specified, provides reasonable assurance that the releases of radioactive materials in gaseous effluents will be kept "as low as is reasonably achievable." This control implements the requirements of 10 CFR Part 50.36a, General Design Criterion 60 of Appendix A to 10 CFR Part 50, and the design objectives given in Section II.D of Appendix I to 10 CFR Part 50. The specified limits governing the use of appropriate portions of the systems were specified as a suitable fraction of the dose design objectives set forth in Sections II.B and II.C of Appendix I, 10 CFR Part 50, for gaseous effluents.

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The GASEOUS RADWASTE TREATMENT SYSTEM is defined in section I-1.1 and consists of charcoal adsorbers and a hold up volume used to reduce the activity released from the offgas system. Further information on the GASEOUS RADWASTE TREATMENT SYSTEM is contained in section II-2.2.

REC 12.4.4 applies to the release of radioactive materials in gaseous effluents from each unit at the site. For units with shared Radwaste Treatment Systems, the gaseous effluents from the shared system are proportioned among the units sharing that system.

Technical Specification 5.5.8, Explosive Gas and Storage Tank Radioactivity Monitoring Program, and the Technical Requirements Manual (TRM) contain requirements for the operation of the offgas recombiner. The Recombiner and dryer add an additional 28 minutes of delay and should be in service when the reactor is operating at a pressure greater than 900 psig. Technical Specification 3.7.6, Main Condenser Offgas contains requirements for activity measured at the air ejector outlet.

REC 12.4.4 implements Technical Specification 5.5.4.f for gaseous effluent treatment systems.

B 12.4 GASEOUS EFFLUENTS AND TOTAL DOSE

B 12.4.5 Ventilation Exhaust Treatment Systems

BASES

The FUNCTIONALITY of the VENTILATION EXHAUST TREATMENT SYSTEMS ensures that the system will be available for use whenever gaseous effluents require treatment prior to release to the environment. The requirement that the appropriate portions of these systems be used, when specified, provides reasonable assurance that the releases of radioactive materials in gaseous effluents will be kept "as low as is reasonably achievable." This specification implements the requirements of 10 CFR Part 50.36a, General Design Criterion 60 of Appendix A to 10 CFR Part 50, and the design objectives given in Section II.D of Appendix I to 10 CFR Part 50. The specified limits governing the use of appropriate portions of the systems were specified as a suitable fraction of the dose design objectives set forth in Sections II.B and II.C of Appendix I, 10 CFR Part 50, for gaseous effluents.

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VENTILATION EXHAUST TREATMENT SYSTEMS are defined in section I-1.1 and consists of charcoal adsorbers and/or HEPA filters used to reduce the iodine or particulate activity released from gaseous exhaust streams. Further information on VENTILATION EXHAUST TREATMENT SYSTEMS is contained in section II-2.2.

REC 12.4.5 implements Technical Specification 5.5.4.f for gaseous effluent treatment systems.

B 12.4 GASEOUS EFFLUENTS

B 12.4.6 Mark I Containment

BASES

REC 12.4.6 provides reasonable assurance that releases from drywell purging operations will not exceed the annual dose limits of 10 CFR Part 20 for UNRESTRICTED AREAS.

The concentration limits in the REC are based on 0.15 mrem/year per unit (1% of the limit for organ dose of Appendix I, 10 CFR Part 50), under the following assumptions:

1. 180 purges per year per unit (Units 2 and 3 only)
2. The entire volume of the drywell is purged
3. All the air in the drywell has the same concentration
4. Radioiodines and particulates contribute an equal fraction of the total calculated offsite dose.

Reference: Dresden Evaluation 97-EFF-001 / Dresden RP Memo #97-020, Drywell Venting Threshold Values, March 1997.

B 12.5 TOTAL DOSE

B 12.5.1 40CFR190 Dose Limits for Members of the Public

BASES

REC 12.5.1 is provided to meet the dose limitations of 40 CFR Part 190 that have been incorporated into 10 CFR Part 20 by 46 FR 18525 as well as the dose limitations specific to Independent Spent Fuel Storage Installation (ISFSI) operations in accordance with 10 CFR 72.104. ISFSI dose contribution dose contribution is in the form of direct radiation as no liquid or gas releases are expected to occur.

The control requires the preparation and submittal of a Special Report whenever the calculated doses due to releases of radioactivity and due to radiation from uranium fuel cycle sources exceed 25 mrem to the total body or any organ except the thyroid, which shall be limited to less than or equal to 75 mrem. For sites containing up to 4 reactors, it is highly unlikely that the resultant dose to a MEMBER OF THE PUBLIC will exceed the dose limits of 40 CFR Part 190 if the individual reactors remain within twice the dose design objectives of Appendix I, and if direct radiation doses from the units (including outside storage tanks, etc.) are kept small. The Special Report will describe a course of action that should result in the limitation of dose to a MEMBER OF THE PUBLIC to within the 40 CFR Part 190 limits. For the purpose of the Special Report, it may be assumed that the dose commitment to the MEMBER OF THE PUBLIC from other uranium fuel cycle sources is negligible, with the exception that dose contributions from other nuclear fuel cycle facilities at the same site or within a radius of 8 km must be considered. If the dose to any member of the public is estimated to exceed the requirements of 40 CFR Part 190, the Special Report with a request for a variance (provided the release conditions resulting in violation of 40 CFR Part 190 have not already been corrected), in accordance with the provisions of 40 CFR 190.11 and 10 CFR 20.2203, is considered to be a timely request and fulfills the requirements of 40 CFR Part 190 until NRC staff action is completed. The variance only relates to the limits of 40 CFR Part 190, and does not apply in any way to the other requirements for dose limitation of 10 CFR Part 20, as addressed in RECs 12.3.1 and 12.4.1. An individual is not considered a MEMBER OF THE PUBLIC during any period in which he/she is engaged in carrying out any operation that is part of the nuclear fuel cycle.

REC 12.5.1 implements Technical Specification 5.5.4.j.

B 12.5 TOTAL DOSE

B 12.5.2 10CFR20 Dose Limits for Members of the Public

BASES

REC 12.5.2 is provided to meet the dose and dose rate limitations of 10 CFR 20.

This control applies to direct exposure of radioactive materials as well as radioactive materials released in gaseous and liquid effluents. 10 CFR 20.1301 sets forth the 100 mrem/year dose limit to members of the public; 2 mrem in any one-hour limit in the unrestricted area; and reiterates that the licensee is also required to meet the 40 CFR 190 standards. 10 CFR 20.1302 provides options to determine compliance to 10 CFR 20.1301. Compliance to the above requirement is based on 10 CFR 20 and 40 CFR 190. The Radioactive Effluent Controls shall implement monitoring, sampling, and analysis of radioactive liquid and gaseous effluents in accordance with 10 CFR 20.1302 and with the methodology and parameters of the ODCM.

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REC 12.5.2 implements Technical Specification 5.5.4.c.

B 12.6 RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

B 12.6.1 Radiological Environmental Monitoring Program

BASES

The Radiological Environmental Monitoring Program required by REC 12.6.1 provides representative measurements of radiation and of radioactive materials in those exposure pathways and for those radionuclides that lead to the highest potential radiation exposures of MEMBERS OF THE PUBLIC resulting from the plant operation. This monitoring program implements Section IV.B.2 of Appendix I to 10 CFR Part 50 and thereby supplements the Radiological Effluent Monitoring Program by verifying that the measurable concentrations of radioactive materials and levels of radiation are not higher than expected on the basis of the effluent measurements and the modeling of the environmental exposure pathways. Guidance for this monitoring program is provided by the Radiological Assessment Branch Technical Position on Environmental Monitoring, Revision 1, November 1979 and NUREG-1302, "Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Boiling Water Reactors," April 1991. The initially specified monitoring program will be effective for at least the first 3 years of commercial operation. Following this period, program changes may be initiated based on operational experience.

The required detection capabilities for environmental sample analyses are tabulated in terms of the lower limits of detection (LLDs). The LLDs required by Table 12.6-3 are considered optimum for routine environmental measurements in industrial laboratories. It should be recognized that the LLD is defined as an a priori (before the fact) limit representing the capability of a measurement system and not as an a posteriori (after the fact) limit for a particular measurement.

Detailed discussion of the LLD, and other detection limits, can be found in Currie, L. A., "Lower Limit of Detection: Definition and Elaboration of a Proposed Position for Radiological Effluent and Environmental Measurements," NUREG/CR-4007 (September 1984), and in the HASL Procedures Manual, HASL-300.

Table 12.6-1 requires "one sample of each community drinking water supply downstream of the plant within 10 kilometers." Drinking water supply is defined as water taken from rivers, lakes, or reservoirs (not well water) that is used for drinking.

Table 12.6-2 and Table 12.6-3 contain specific requirements if a drinking water pathway exists. For the purposes of these tables, drinking water pathway is defined as being supplied via a community water system as defined in 40 CFR Part 141, meaning a public water system which serves at least 15 service connections used by year-round residents or regularly serves at least 25 year-round residents.

B 12.6 RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

B 12.6.2 Land Use Census

BASES

REC 12.6.2 is provided to ensure that changes in the use of areas at and beyond the SITE BOUNDARY are identified and that modifications to the Radiological Environmental Monitoring Program given in the ODCM are made if required by the results of this census. The best information from the door-to-door survey, from aerial survey, or from consulting with local agricultural authorities should be used. This census satisfies the requirements of Section IV.B.3 of Appendix I to 10 CFR Part 50. An annual garden census will not be required since the licensee will assume that there is a garden at the nearest residence in each sector for dose calculations.

A census identifying all gardens and all milk animals in all sectors within 5 km (3 miles) is not performed. With an elevated stack, the potential exists for the highest D/Q for a given sector to exist beyond the RESTRICTED AREA / SITE BOUNDARY. As seen in Tables 4.3 and 4.4, the highest D/Qs in each sector are at the RESTRICTED AREA BOUNDARY with the exception of the SW and WSW sectors, where the highest D/Qs are 6 meters and 60 meters, respectively, beyond the RESTRICTED AREA BOUNDARY but well within the SITE BOUNDARY. Therefore, using the RESTRICTED AREA / SITE BOUNDARY D/Q values for dose calculations involving ground deposition is a conservative and acceptable practice.

B 12.6 RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

B 12.6.3 Interlaboratory Comparison Program

BASES

The requirement for participation in an Interlaboratory Comparison Program is provided to ensure that independent checks on the precision and accuracy of the measurements of radioactive material in environmental samples matrices are performed as part of the quality assurance program for environmental monitoring in order to demonstrate that the results are valid for the purposes of Section IV.B.2 of Appendix I to 10 CFR Part 50.

Due to the unconventional nature of some media sampled for the REMP (e.g., fish), interlaboratory comparisons can be satisfactorily performed using samples in equivalent media. For example, the fish media is equivalent to water after processing for analysis.

- B 12.7 METEOROLOGICAL MONITORING PROGRAM (Not Applicable)
- B 12.7.1 Meteorological Monitoring Program (Not Applicable)

B 12.8 ON-SITE GROUNDWATER AND STORM SEWER MONITORING

B 12.8.1 On-Site Groundwater and Storm Sewer Monitoring

BASES

This REC institutionalizes groundwater and storm sewer monitoring at the station. Monitoring is performed primarily to identify underground leaks of radioactive systems.

OFFSITE DOSE CALCULATION MANUAL

Part II, METHODOLOGY AND PARAMETERS

DRESDEN STATION

UNITS 1, 2, 3

1.0 INTRODUCTION - ODCM General Information

The Offsite Dose Calculation Manual (ODCM) contains the following:

- The basic concepts applied in calculating offsite doses from plant effluents.
- The regulations and requirements for the ODCM and related programs.
- The methodology and parameters for the offsite dose calculations to assess impact on the public and compliance with regulations.

The methodology detailed in this manual is intended for the calculation of radiation doses above background during routine (i.e., non-accident) conditions. The calculations are normally performed using a computer program. Manual calculations may be performed in lieu of the computer program.

The dose effects of airborne radioactivity releases predominately depend on meteorological conditions (wind speed, wind direction, and atmospheric stability). For airborne effluents, the dose calculations prescribed in this manual are based on historical average atmospheric conditions. This methodology is appropriate for estimating annual average dose effects and is stipulated in the Bases Section of the Radioactive Effluent Controls.

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1.1 Structure of the ODCM

Part I of the ODCM is the Radioactive Effluents Controls (RECs), and contains the monitoring requirements and surveillances used to comply with Technical Specifications and regulatory requirements.

Part II of the ODCM is the Methodology and Parameters, and contains methods, equations, assumptions, and parameters for calculation of radiation doses from plant effluents.

1.2 Regulations

Note: Any information provided in the ODCM concerning specific regulations are not a substitute for the regulations as found in the Code of Federal Regulations (CFR) or Technical Specifications.

1.2.1 Code of Federal Regulations

Various sections of the Code of Federal Regulations (CFR) require nuclear power stations to be designed and operated in a manner that limits the radiation exposure to members of the public. These sections specify limits on offsite radiation doses, dose rates, and effluent radioactivity concentrations above background and they also require releases of radioactivity to be "As Low As Reasonably Achievable." These requirements are contained in 10CFR20, 10CFR50, and 40CFR190. In addition, 40CFR141 imposes limits on the concentration of radioactivity in drinking water provided by the operators of public water systems.

- 10CFR20, Standards for Protection Against Radiation
10CFR20 dose limits are summarized in Table 1-1.

- ALARA Provisions (Appendix I to 10CFR50)

Sections 50.34a and 50.36a of 10CFR50 require that the nuclear plant design and the station RECs have provisions to keep levels of radioactive materials in effluents to unrestricted areas "As Low As Reasonably Achievable" (ALARA). Although 10CFR50 does not impose specific limits on releases, it does provide numerical design objectives and suggested limiting conditions for operation. According to Section I of Appendix I of 10CFR50, conforming to the guidelines of Appendix I "shall be deemed a conclusive showing of compliance with the "As Low As Reasonably Achievable" requirements of 10CFR50.34a and 50.36a."

An applicant must use calculations to demonstrate conformance with the design objective dose limits of Appendix I. The calculations are to be based on models and data such that the actual radiation exposure of an individual is "unlikely to be substantially underestimated" (see 10CFR50 Appendix I, Section III.A.1).

The guidelines in Appendix I call for an investigation, corrective action and a report to the NRC whenever the calculated dose due to the radioactivity released in a calendar quarter exceeds one-half of an annual design objective. The guidelines also require a surveillance program to monitor releases, monitor the environment, and identify changes in land use.

- 40CFR190, Environmental Radiation Protection Standards for Nuclear Power Operations

Under an agreement between the NRC and the EPA, the NRC stipulated to its licensees in Generic Letter 79-041 that "Compliance with Radiological Effluent Technical Specifications (RETS), NUREG-0473 (Rev.2) for BWR's, implements the LWR provisions to meet 40CFR190." (See References 103 and 49.)

The regulations of 40CFR190 limit radiation doses received by members of the public as a result of operations that are part of the uranium fuel cycle. Operations must be conducted in such a manner as to provide reasonable assurance that the annual dose equivalent to any member of the public due to radiation and to planned discharges of radioactive materials does not exceed the following limits:

- 25 mrem to the total body
- 75 mrem to the thyroid
- 25 mrem to any other organ

An important difference between the design objectives of 10CFR50 and the limits of 40CFR190 is that 10CFR50 addresses only doses due to radioactive effluents. 40CFR190 limits doses due to effluents and to radiation sources maintained on site. See Section 1.2.3 for further discussion of the differences between the requirements of 10CFR50 Appendix I and 40CFR190.

- 10CFR72, Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor-Related Greater Than Class C Waste

10CFR72.104 states that annual dose to any real individual located beyond the controlled area must not exceed the following:

- 25 mrem to the total body
- 75 mrem to the thyroid
- 25 mrem to any other critical organ

as a result of planned discharges of radioactive material to the environment, direct radiation from ISFSI operation, and other radiation from uranium fuel cycle operation (40CFR190).

These requirements are consistent with the requirements of 40CFR190.

- 40CFR141, National Primary Drinking Water Regulations

The following radioactivity limits for community water systems were established in the July, 1976 Edition of 40CFR141:

- Combined Ra-226 and Ra-228: ≤ 5 pCi/L.
- Gross alpha (particle activity including Ra-226 but excluding radon and uranium): ≤ 15 pCi/L.
- The average annual concentration of beta particle and photon radioactivity from man-made radionuclides in drinking water shall not produce an annual dose equivalent to the total body or any internal organ greater than 4 mrem/yr (e.g., 20,000 pCi/L ^3H).

The regulations specify procedures for determining the values of annual average radionuclide concentration that produce an annual dose equivalent of 4 mrem. The responsibility for monitoring radioactivity in a community water system falls on the supplier of the water. The Dresden Station has requirements related to 40CFR141 in the RECs.

1.2.2 Offsite Dose Calculation Manual

The NRC in Generic Letter 89-01 defines the ODCM as follows (not verbatim) (see Reference 90):

The Offsite Dose Calculation Manual (ODCM) shall contain the methodology and parameters used in the calculation of offsite doses resulting from radioactive gaseous and liquid effluents, in the calculation of gaseous and liquid effluent monitoring Alarm/Trip Setpoints, and in the conduct of the Radiological Environmental Monitoring Program. The ODCM shall also contain (1) the Radioactive Effluent Controls and Radiological Environmental Monitoring Programs and (2) descriptions of the Information that should be included in the Annual Radiological Environmental Operating and Annual Radioactive Effluent Release Reports.

Additional requirements for the content of the ODCM are contained throughout the text of the RECs.

1.2.3 Overlapping Requirements

In 10CFR20, 10CFR50, and 40CFR190, there are overlapping requirements regarding offsite radiation dose and dose commitment to the total body. In 10CFR20.1301, the total effective dose equivalent (TEDE) to a member of the public is limited to 100 mrem per calendar year. In addition, Appendix I to 10CFR50 establishes design objectives on annual total body dose or dose commitment of 3 mrem per reactor for liquid effluents and 5 mrem per reactor for gaseous effluents (see 10CFR50 Appendix I, Sections II.A and II.B.2(a)). Finally, 40CFR190 limits annual total body dose or dose commitment to a member of the public to 25 mrem due to all uranium fuel cycle operations.

While these dose limits/design objectives appear to overlap, they are different and each is addressed separately by the RECs. Calculations are made and reports are generated to demonstrate compliance to all regulations. Refer to Tables 1-1, 1-2, and 1-3 for additional information regarding instantaneous effluent limits, design objectives, and regulatory compliance.

1.2.4 Dose Receiver Methodology

Table 1-2 lists the location of the dose recipient and occupancy factors, if applicable. Dose is assessed at the locations in the unrestricted area where the combination of existing pathways and receptor age groups indicates the maximum potential exposures. The dose calculation methodology is consistent with the methodology of Regulatory Guide 1.109 (Reference 6) and NUREG 0133 (Reference 14). Dose is therefore calculated to a maximum individual. The maximum individual is characterized as "maximum" with regard to food consumption, occupancy, and other usage of the area in the vicinity of the plant site. Such a "maximum individual" represents reasonable deviation from the average for the population in general. In all physiological and metabolic respects, the maximum individual is assumed to have those characteristics that represent averages for their corresponding age group. Thus, the dose calculated is very conservative compared to the "average" (or typical) dose recipient who does not go out of the way to maximize radioactivity uptakes and exposure.

Table 1-3 relates the dose component (or pathway) to specific ODCM equations and the appropriate regulation.

In the event received dose approaches or exceeds regulatory guidelines or limits, further study should be conducted to develop a more accurate model of the receiver(s) and the dose(s) received.

1.2.5 Exposure Pathways

1.2.5.1 Introduction

Figure 1-1 illustrates some of the potential radiation exposure pathways to humans due to routine operation of a nuclear power station. These exposure pathways may be grouped into three categories:

- **Airborne Releases**
Exposures resulting from radioactive materials released with gaseous effluents to the atmosphere.
- **Liquid Releases**
Exposures resulting from radioactive materials released with liquid discharges to bodies of water.
- **Radiation from Contained Sources**
Exposures to radiation from contained radioactive sources.

When performing radiation dose calculations, only exposure pathways that significantly contribute ($\geq 10\%$) to the total dose of interest need to be evaluated. The radiation dose from air and water exposure pathways are routinely evaluated. (See Regulatory Guide 1.109, Reference 6.)

1.2.5.2 Airborne Releases

For airborne releases of radioactivity (Figure 1-1), the NRC considers the following pathways of radiation exposure of persons:

- External radiation from radioactivity airborne in the effluent plume.
- External radiation from radioactivity deposited by the plume on the ground.
- Ingestion of radioactivity on, or in, edible vegetation (from direct plume deposition or from the transfer of radioactivity deposited on the soil).
- Ingestion of radioactivity that entered an animal food product (milk or meat) because the animal ingested contaminated feed, with the contamination due either to direct deposition on foliage or to uptake from the soil.
- Inhalation of radioactivity in the plume.

Dresden considers these same pathways with the exception that the transfer of radioactivity from soil to vegetation is omitted. This pathway was determined to be of minimal significance in relation to the other airborne exposure pathways.

1.2.5.3 Liquid Releases

For liquid releases of radioactivity (Figure 1-1), the NRC considers the following pathways of radiation exposure of persons:

- Direct exposure to radioactivity in water while engaging in recreational activities such as swimming and boating.
- Exposure to radiation from shoreline sediments contaminated by water containing radioactivity from station liquid discharges.
- Ingestion of edible vegetation contaminated by irrigation with water containing radioactivity from station liquid discharges.
- Ingestion of radioactivity from animal food products (milk or meat) resulting from the animal either drinking water contaminated by radioactive liquid effluents or from the animal eating feed or vegetation contaminated by irrigation with such water.
- Ingestion of aquatic food (e.g., fish) obtained from the body of water to which radioactive station effluents are discharged.
- Ingestion (drinking) of potable water contaminated by radioactive liquid effluents discharged from the station.

Dresden considers the latter two of these pathways as significant. For the aquatic food pathway, only fish is considered since it is the only significant locally produced aquatic food consumed by humans.

The station omits the pathways involving irrigation and animal consumption of contaminated water because these pathways were determined to be insignificant. The stations also omit the pathway of radiation exposure from shoreline sediment because this pathway was also found to be insignificant.

The station has also verified that the dose contribution to people participating in water recreational activities (swimming and boating) is negligible. This pathway was not addressed explicitly in Regulatory Guide 1.109. Thus, the station also omits dose assessments for the water recreational activities pathway.

Periodically the Illinois Army Corps of Engineers dredges silt and debris from the riverbeds downstream of Dresden station. As a part of the land use census, Dresden will determine if the Corps performed dredging within one mile of the discharge point. If so, Dresden will obtain spoils samples, through it's REMP vendor, for analysis. The impact to the offsite dose will be evaluated on a case-by-case basis and added to the station annex of the ODCM when applicable.

1.2.5.4 Radiation from Contained Sources

Radiation from contained sources is discussed in Part II, Section 5.

Table 1-1
Regulatory Dose Limit Matrix

| REGULATION | DOSE TYPE | DOSE LIMIT(s) | | ODCM Section |
|---------------------------------|--|--|----------|--------------|
| Airborne Releases: | | (quarterly) | (annual) | |
| 10CFR50 App. I ³ | Gamma Dose to Air due to Noble Gas Radionuclides (per reactor unit) | 5 mrad | 10 mrad | 4.2.2.1 |
| | Beta Dose to Air Due to Noble Gas Radionuclides (per reactor unit) | 10 mrad | 20 mrad | 4.2.2.2 |
| | Organ Dose Due to Specified Non-Noble Gas Radionuclides (per reactor unit) | 7.5 mrem | 15 mrem | 4.2.3 |
| | Total Body Dose (per reactor unit) | 2.5 mrem | 5 mrem | 4.2.2.3 |
| | Skin Dose (per reactor unit) | 7.5 mrem | 15 mrem | 4.2.2.4 |
| Technical Specifications | Total Body Dose Rate Due to Noble Gas Radionuclides (instantaneous limit, per site) | 500 mrem/yr | | 4.2.1.2 |
| | Skin Dose Rate Due to Noble Gas Radionuclides (instantaneous limit, per site) | 3,000 mrem/yr | | 4.2.1.3 |
| | Organ Dose Rate Due to Specified Non-Noble Gas Radionuclides (instantaneous limit, per site) | 1,500 mrem/yr | | 4.2.1.4 |
| Liquid Releases: | | (quarterly) | (annual) | |
| 10CFR50 App. I ³ | Total Body Dose (per reactor unit) | 1.5 mrem | 3 mrem | 3.4.1 |
| | Organ Dose (per reactor unit) | 5 mrem | 10 mrem | 3.4.1 |
| Technical Specifications | The concentration of radioactivity in liquid effluents released to unrestricted areas | Ten times the values listed in 10CFR20 Appendix B; Table 2, Column 2 | | 3.2 |
| Total Doses¹: | | | | |
| 10CFR20.1301(a)(1) | Total Effective Dose Equivalent ⁴ | 100 mrem/yr | | 5.4.3 |
| 10CFR20.1301(d) and 40CFR190 | Total Body Dose | 25 mrem/yr | | 5.4.1 |
| | Thyroid Dose | 75 mrem/yr | | 5.4.2 |
| | Other Organ Dose | 25 mrem/yr | | 5.4.2 |
| Other Limits: | | | | |
| 40CFR141 ² | Total Body Dose Due to Drinking Water From Public Water Systems | 4 mrem/yr | | 3.4 |
| | Organ Dose Due to Drinking Water From Public Water Systems | 4 mrem/yr | | 3.4 |

- ¹ These doses are calculated considering all sources of radiation and radioactivity in effluents.
- ² 40CFR141 limits are not directly applicable to nuclear power stations. They are applicable to the owners or operators of public water systems. However, the Dresden RECs require assessment of compliance with these limits.
- ³ Note that 10CFR50 provides design objectives, not limits.
- ⁴ Compliance with 10CFR20.1301(a)(1) is demonstrated by compliance with 40CFR190.

Table 1-2
Dose Assessment Receivers

| Dose Component or Pathway | Location; Occupancy if Different than 100% |
|---|--|
| "Instantaneous" dose rates from airborne radioactivity | Unrestricted area boundary location that results in the maximum dose rate |
| "Instantaneous" concentration limits in liquid effluents | Point where liquid effluents enter the unrestricted area |
| Annual average concentration limits for liquid effluents | Point where liquid effluents enter the unrestricted area |
| Direct dose from contained sources | Receiver spends part of this time in the controlled area and the remainder at his residence or fishing nearby; occupancy factor is considered and is site-specific. See Table 5-1 for occupancy factors. |
| Direct dose from airborne plume | Receiver is at the location at or beyond the unrestricted area boundary that results in the maximum dose |
| Dose due to radioiodines, tritium, and particulates with half-lives greater than 8 days for inhalation, ingestion of vegetation, milk and meat, and ground plane exposure pathways. | Receiver is at the location in the unrestricted area where the combination of existing pathways and receptor age groups indicates the highest potential exposures. |
| Ingestion dose from drinking water | The drinking water pathway is considered as an additive dose component in this assessment only if the public water supply serves the community immediately adjacent to the plant. |
| Ingestion dose from eating fish | The receiver eats fish from the receiving body of water |
| Total Organ Doses | Summation of ingestion/inhalation doses |
| Total Effective Dose Equivalent | Summation of above data |

Table 1-3
Dose Component/Regulation Matrix

| Dose Component or Pathway | Reference equation; Comments | Regulation in which dose component is utilized | | |
|--|---|--|----------|------------------|
| | | 10CFR20 | 40CFR190 | 10CFR50 App I |
| "Instantaneous" dose rates from airborne radioactivity (RECs requirement only) | 4-1: Total Body 4-2: Skin 4-6: Organ | X ⁽²⁾ | | |
| "Instantaneous" concentration limits in liquid effluents | 3-1: Ten times the limits of 10CFR20, Appendix B, Table 2, Col. 2, and 2×10^{-4} $\mu\text{Ci/ml}$ total gaseous activity. | X ⁽²⁾ | | |
| Direct dose from contained sources | 5-1 | X | X | |
| Direct dose from airborne plume | 4-7: Gamma air dose 4-8: Beta air dose 4-12: Total body dose 4-13: Skin dose | X | X | X X X X |
| Direct dose from radioactivity deposited on the ground | 4-15 | X | X | X |
| Inhalation dose from airborne effluents | 4-18 ⁽¹⁾ | X | X | X |
| Ingestion dose from vegetables | 4-19, 4-20, and 4-26 ⁽¹⁾ | X | X | X |
| Ingestion dose from milk | 4-19 and 4-22 ⁽¹⁾ | X | X | X |
| Ingestion dose from meat | 4-19 and 4-24 ⁽¹⁾ | X | X | X |
| Ingestion dose from drinking water | 3-4 ⁽¹⁾ | X | X | X |
| Ingestion dose from eating fish | 3-5 ⁽¹⁾ | X | X | X |
| Total Organ Doses | 4-14 | | X | X |
| Total Effective Dose Equivalent | 5-5 ⁽³⁾ | X | | |

¹ Ingestion/inhalation dose assessment is evaluated for adult/teen/child and infant for 10CFR50 Appendix I compliance and for an adult for 10CFR20/40CFR190 compliance. Ingestion/inhalation dose factors are taken from Reg. Guide 1.109 (Reference 6) for 10CFR50 Appendix I compliance and FGR-11 (Reference 93) for 10CFR20 / 40CFR190 compliance.

² Technical Specifications have been revised to allow 10 times the 10CFR20 value or specifically states the maximum instantaneous dose rate limit.

³ Compliance with the Total Effective Dose Equivalent limits of 10CFR20 is demonstrated by compliance with 40CFR190. It may also be necessary to address dose from on-site activity by members of the public.

Table 1-4 (Page 1 of 2)
Simplified Chart of Offsite Dose Calculations²

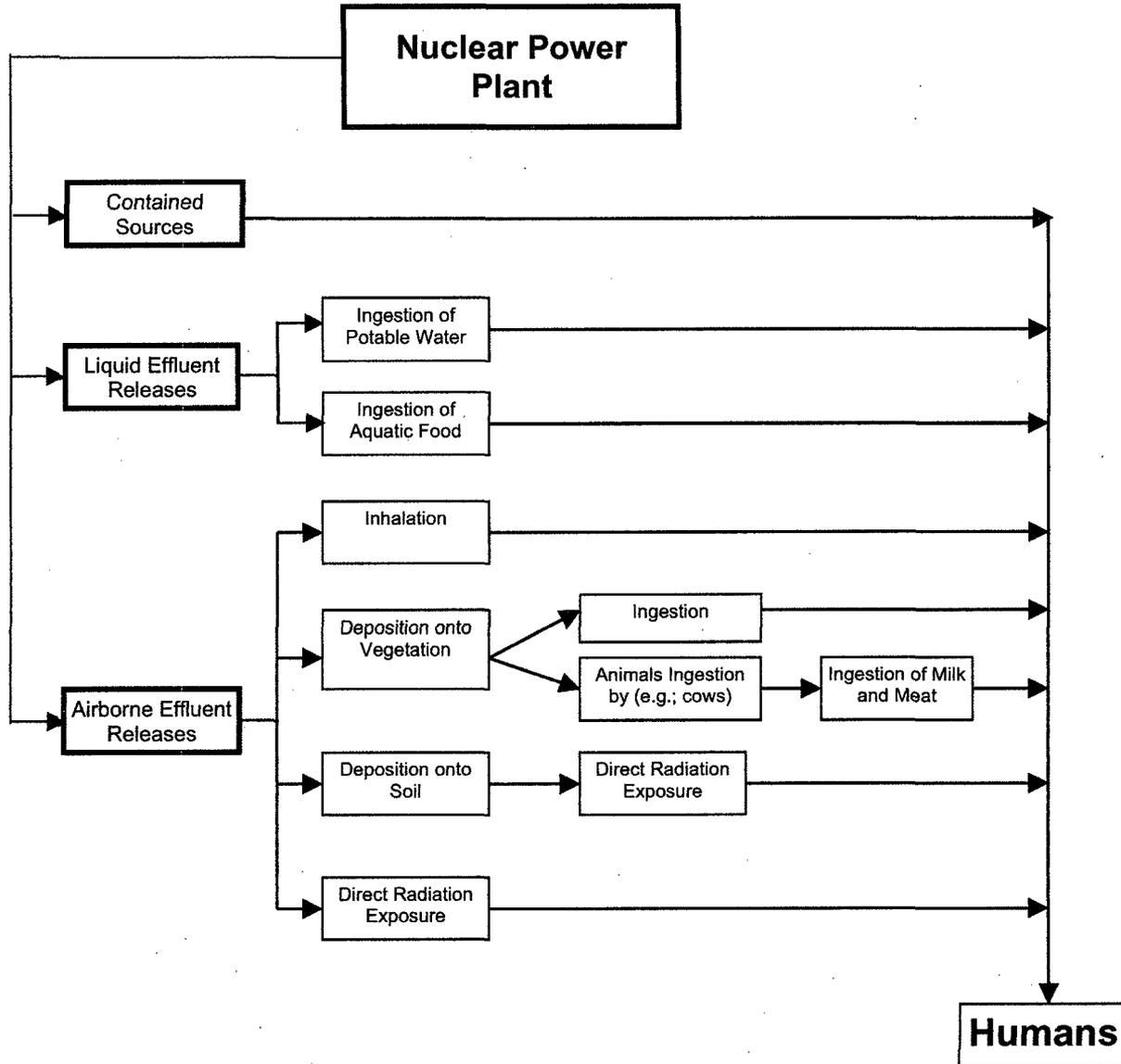
| Category | Radionuclides | Pathway | Text Section | Receptor | Code and Limits | Frequency of Calculation ¹ | |
|-------------------------------|---|----------------------------------|--|------------------------------|---|---|---------|
| Airborne Releases: | | | | | | | |
| Noble Gases: | | Plume γ^a | 2.2.4 4.2.1.2 | Total Body | RECs: 500 mrem/yr Instantaneous | As required by station procedure | |
| | | Plume γ^a and β^b | 2.2.4 4.2.1.3 | Skin | RECs: 3000 mrem/yr Instantaneous | | |
| | | Plume γ^a | 4.2.2.1 | Air ⁴ | 10CFR50 ³ : 5 mrad/qtr, 10 mrad/yr | Monthly | |
| | | Plume β^b | 4.2.2.2 | | 10CFR50 ³ : 10 mrad/qtr, 20 mrad/yr | | |
| Non-Noble Gases: | | Inhalation ^b | 4.2.1.4 | Adult (Any organ) | RECs: 1500 mrem/yr Instantaneous | As required by station procedure | |
| | | Ground Deposition ^c | 4.2.3.1 | Total Body | 10CFR50 ³ : 7.5 mrem/qtr, 15 mrem/yr | Monthly and Annually | |
| | | Inhalation Produce ^c | 4.2.3.2 | Four Age groups (All Organs) | | | |
| | | Milk ^d | 4.2.3.3.1 | | | | |
| Meat ^d | 4.2.3.3.2 | | | | | | |
| Leafy Vegetables ^c | 4.2.3.3.3 | | | | | | |
| Liquid Releases: | | | | | | | |
| Non-Noble Gases | | All | Water | 3.2 | RECs, 10 times 10CFR20 Appendix B, Table 2, Col. 2; 2×10^{-4} total Noble Gases | As required by station procedure | |
| | | Non-Noble Gases | Water ^e and Fish ^f | 3.4.2 | Total Body | 10CFR50 ³ : 1.5 mrem/qtr, 3 mrem/yr | Monthly |
| | | | | | 4 Age Groups (All Organs) | 10CFR50 ³ : 5 mrem/qtr, 10 mrem/yr | |
| | Water ^e | 3.4.3 | Adult (Total Body and all Organs) | 40CFR141: 4 mrem/yr | As required by RECs | | |
| Uranium Fuel Cycle: | | | | | | | |
| All | All releases plus direct radiation from contained sources | 5.4 | Total Body | 40CFR190: 25 mrem/yr | Annually | | |
| | | | Thyroid (Adult) | 40CFR190: 75 mrem/yr | | | |
| | | | All Other Organs (Adult) | 40CFR190: 25 mrem/yr | | | |
| TEDE: | All | External (DDE) + Internal (CEDE) | 5.5 | Total Body + organs (Adult) | 10CFR20: 100 mrem/yr | Annually | |

Table 1-4 (Page 2 of 2)

Notes for Table 1-4:

1. See RECs for exact requirements.
2. In addition to the calculations shown in this figure, monthly projections of doses due to radioactive materials are required for gaseous and liquid effluents. Projections of drinking water doses are required at least once per 92 days. See RECs.
3. 10 CFR 50 prescribes design objectives, not limits.
4. If the air dose is exceeded, doses to the total body and skin are calculated. Total body objectives are 2.5 mrem/qtr and 5.0 mrem/year; the skin dose objectives are 7.5 mrem/qtr and 15 mrem/year.
- a. Evaluated at the restricted area boundary.
- b. Evaluated at the location of maximum offsite χ/Q .
- c. Ground plane and inhalation pathways are considered to be present at all offsite locations.
- d. Evaluated at the location in the unrestricted area where the combination of existing pathways and receptor age groups indicates the maximum potential exposures.
- e. Evaluated for the nearest downstream community water supply. The flow and dilution factors specified in Table 3-2 are used.
- f. Evaluated for fish caught in the near-field region downstream of plant using the flow and dilution factors specified in Table 3-2.

Figure 1 - 1
Radiation Exposure Pathways to Humans



1.3 Offsite Dose Calculation Parameters

This section contains offsite dose calculation parameter factors, or values not specific only to one of the gas, liquid, or total dose chapters. Additional parameters are provided in the Sections 3, 4, and 5 of the ODCM.

1.3.1 10CFR50 Dose Commitment Factors

The dose commitment factors for 10CFR50 related calculations are exactly those provided in Regulatory Guide 1.109 (Reference 6). The following table lists the parameters and the corresponding data tables in the RG 1.109:

| <u>PATHWAY</u> | <u>ADULT</u> | <u>TEENAGER</u> | <u>CHILD</u> | <u>INFANT</u> |
|----------------|-------------------------|-------------------------|-------------------------|-------------------------|
| Inhalation | RG 1.109: Table E-7 | RG 1.109: Table E-8 | RG 1.109: Table E-9 | RG 1.109: Table E-10 |
| Ingestion | RG 1.109: Table E-11 | RG 1.109: Table E-12 | RG 1.109: Table E-13 | RG 1.109: Table E-14 |

These tables are contained in Regulatory Guide 1.109 (Reference 6). Each table (E-7 through E-14) provides dose factors for seven organs for each of 73 radionuclides. For radionuclides not found in these tables, dose factors will be derived from ICRP 2 (Reference 50) or NUREG-0172 (Reference 51).

1.3.2 10CFR20 Dose Commitment Factors

The dose commitment factors for 10CFR20 related calculations are exactly those provided in Federal Guidance Report No. 11 (Reference 93). The following table lists the parameters and the corresponding data tables in the FGR:

| <u>PATHWAY</u> | <u>AVERAGE INDIVIDUAL</u> |
|----------------|---------------------------|
| Inhalation | FGR#11: Table 2.1 |
| Ingestion | FGR#11: Table 2.2 |

The factors used in offsite dose calculations are for the seven organs (Gonad, Breast, Lung, R. Marrow, B. Surface, Thyroid, and Remainder organs) but do not include the Effective (weighted) values. The factors in FGR#11 have units of Seiverts/Becquerel (Sv/Bq). To convert to traditional units of mrem/pCi multiply the factors by 3.7E+3.

1.4 References

The references listed below were transferred from the previous ODCM revision that was common to all former Commonwealth Edison nuclear stations. The references not applicable to Dresden have been deleted, however the numbering has been preserved for ease of reference management throughout the ODCM document; therefore, reference numbering is not sequential.

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Table 1-5
Miscellaneous Dose Assessment Factors: Consumption Parameters

| Type | Variable | Infant | Child | Teenager | Adult |
|---------------------|-------------------------------|--------|--------|----------|--------|
| Air | R_a (m ³ /yr) | 1400 | 3700 | 8000 | 8000 |
| Milk | U_a^m (L/yr) | 330 | 330 | 400 | 310 |
| Produce | U_a^v (kg/yr) | 0 | 520 | 630 | 520 |
| Leafy Vegetables | U_a^F (kg/yr) | 0 | 26 | 42 | 64 |
| Meat | U_a^F (kg/yr) | 0 | 41 | 65 | 110 |
| Water | U_a^w [L/hr] | 0.038 | 0.058 | 0.058 | 0.083 |
| Fish | U_a^f [kg/hr] | 0 | 7.9E-4 | 1.8E-3 | 2.4E-3 |

From Regulatory Guide 1.109, Table E-5. Fish and Water usage factors are converted to units per hour.

Table 1-6 (Page 1 of 2)
Radiological Decay Constants

| <u>Isotope</u> | <u>λ_i</u> | <u>Isotope</u> | <u>λ_i</u> | <u>Isotope</u> | <u>λ_i</u> |
|----------------|-------------------------------|----------------|-------------------------------|----------------|-------------------------------|
| H-3 | 6.44E-06 | As-77 | 1.79E-02 | Pd-109 | 5.15E-02 |
| Be-7 | 5.4E-04 | Se-73 | 9.69E-02 | Cd-109 | 6.22E-05 |
| C-14 | 1.38E-08 | Se-75 | 2.41E-04 | In-111 | 1.02E-02 |
| F-18 | 3.78E-01 | Br-77 | 1.21E-02 | In-115m | 1.59E-01 |
| Na-22 | 3.04E-05 | Br-80 | 2.38E+00 | In-116 | 7.66E-01 |
| Na-24 | 4.62E-02 | Br-82 | 1.96E-02 | Sn-113 | 2.51E-04 |
| Mg-27 | 4.39E+00 | Br-83 | 2.90E-01 | Sn-117m | 2.12E-03 |
| Mg-28 | 3.31E-02 | Br-84 | 1.30E+00 | Sn-119m | 9.85E-05 |
| Al-26 | 1.10E-10 | Br-85 | 1.45E+01 | Sb-117 | 2.48E-01 |
| Al-28 | 1.85E+01 | Kr-79 | 1.98E-02 | Sb-122 | 1.07E-02 |
| P-32 | 2.02E-03 | Kr-81 | 3.77E-10 | Sb-124 | 4.80E-04 |
| Cl-38 | 1.12E+00 | Kr-83m | 3.79E-01 | Sb-125 | 2.86E-05 |
| Ar-41 | 3.79E-01 | Kr-85m | 1.55E-01 | Sb-126 | 2.33E-03 |
| K-40 | 6.19E-14 | Kr-85 | 7.38E-06 | Ag-108m | 6.23E-07 |
| K-42 | 5.61E-02 | Kr-87 | 5.44E-01 | Ag-108 | 1.75E+01 |
| K-43 | 3.07E-02 | Kr-88 | 2.44E-01 | Ag-110m | 1.16E-04 |
| Ca-47 | 6.37E-03 | Kr-90 | 7.71E+00 | Ag-111 | 3.87E-03 |
| Sc-44 | 1.76E-01 | Rb-84 | 8.78E-04 | Te-121m | 1.88E-04 |
| Sc-46m | 1.33E+02 | Rb-86 | 1.55E-03 | Te-121 | 1.72E-03 |
| Sc-46 | 3.44E-04 | Rb-87 | 1.67E-15 | Te-123m | 2.41E-04 |
| Sc-47 | 8.44E-03 | Rb-88 | 2.33E+00 | Te-125m | 4.98E-04 |
| Ti-44 | 1.67E-06 | Rb-89 | 2.69E+00 | Te-125 | 0.00E+00 |
| V-48 | 1.81E-03 | Sr-85 | 4.45E-04 | Te-127m | 2.65E-04 |
| Cr-51 | 1.04E-03 | Sr-87m | 2.47E-01 | Te-127 | 7.41E-02 |
| Mn-52m | 1.94E+00 | Sr-89 | 5.71E-04 | Te-129m | 8.59E-04 |
| Mn-52 | 5.16E-03 | Sr-90 | 2.77E-06 | Te-129 | 5.96E-01 |
| Mn-54 | 9.23E-05 | Sr-91 | 7.29E-02 | Te-131m | 2.31E-02 |
| Mn-56 | 2.69E-01 | Sr-92 | 2.56E-01 | Te-131 | 1.66E+00 |
| Fe-52 | 8.37E-02 | Y-86 | 4.70E-02 | Te-132 | 8.86E-03 |
| Fe-55 | 2.93E-05 | Y-87 | 8.63E-03 | Te-134 | 9.93E-01 |
| Fe-59 | 6.47E-04 | Y-88 | 2.71E-04 | I-123 | 5.28E-02 |
| Co-57 | 1.07E-04 | Y-90 | 1.08E-02 | I-124 | 6.91E-03 |
| Co-58 | 4.08E-04 | Y-91m | 8.35E-01 | I-125 | 4.80E-04 |
| Co-60 | 1.50E-05 | Y-91 | 4.94E-04 | I-130 | 5.61E-02 |
| Ni-63 | 7.90E-07 | Y-92 | 1.96E-01 | I-131 | 3.59E-03 |
| Ni-65 | 2.75E-01 | Y-93 | 6.86E-02 | I-132 | 3.01E-01 |
| Cu-64 | 5.46E-02 | Zr-95 | 4.51E-04 | I-133 | 3.33E-02 |
| Cu-67 | 4.67E-04 | Zr-97 | 4.10E-02 | I-134 | 7.89E-01 |
| Cu-68 | 8.31E+01 | Nb-94 | 3.90E-09 | I-135 | 1.05E-01 |
| Zn-65 | 1.18E-04 | Nb-95 | 8.00E-03 | Xe-127 | 7.93E-04 |
| Zn-69m | 5.04E-02 | Nb-97m | 4.15E+01 | Xe-129m | 3.25E-03 |
| Zn-69 | 7.46E-01 | Nb-97 | 5.76E-01 | Xe-131m | 2.44E-03 |
| Ga-66 | 7.37E-02 | Mo-99 | 1.05E-02 | Xe-133m | 1.32E-02 |
| Ga-67 | 8.85E-03 | Tc-99m | 1.15E-01 | Xe-133 | 5.51E-03 |
| Ga-68 | 6.10E-01 | Tc-101 | 2.92E+00 | Xe-135m | 2.70E+00 |
| Ga-72 | 4.91E-02 | Tc-104 | 2.31E+00 | Xe-135 | 7.61E-02 |
| Ge-77 | 6.13E-02 | Ru-97 | 9.96E-03 | Xe-137 | 1.08E+01 |
| As-72 | 2.67E-02 | Ru-103 | 7.34E-04 | Xe-138 | 2.94E+00 |
| As-73 | 3.6E-04 | Ru-105 | 1.56E-01 | Cs-129 | 2.16E-02 |
| As-74 | 1.62E-03 | Ru-106 | 7.84E-05 | Cs-132 | 4.46E-03 |
| As-76 | 2.63E-02 | Rh-106 | 8.33E+01 | Cs-134 | 3.84E-05 |

Table 1-6 (Page 2 of 2)
Radiological Decay Constants

| <u>Isotope</u> | λ_i | <u>Isotope</u> | λ_i | <u>Isotope</u> | λ_i |
|----------------|-------------|----------------|-------------|----------------|-------------|
| Cs-136 | 2.19E-03 | Nd-149 | 4.01E-01 | Pt-195m | 7.18E-03 |
| Cs-137 | 2.62E-06 | Pm-145 | 4.47E-06 | Pt-197 | 3.79E-02 |
| Cs-138 | 1.29E+00 | Pm-148m | 6.99E-04 | Au-195m | 8.15E+01 |
| Cs-139 | 4.41E+00 | Pm-148 | 5.38E-03 | Au-195 | 1.58E-04 |
| Ba-131 | 2.45E-03 | Pm-149 | 1.31E-02 | Au-198 | 1.07E-02 |
| Ba-133m | 1.78E-02 | Sm-153 | 1.48E-02 | Au-199 | 9.20E-03 |
| Ba-133 | 7.53E-06 | Eu-152 | 5.82E-06 | Hg-197 | 2.91E-02 |
| Ba-135m | 2.41E-02 | Eu-154 | 8.99E-06 | Hg-203 | 6.20E-04 |
| Ba-137m | 1.63E+01 | Eu-155 | 1.59E-05 | Tl-201 | 9.49E-03 |
| Ba-137 | 0.00E+00 | Gd-153 | 1.20E-04 | Tl-206 | 9.90E+00 |
| Ba-139 | 4.99E-01 | Dy-157 | 8.60E-02 | Tl-208 | 1.36E+01 |
| Ba-140 | 2.26E-03 | Er-169 | 3.07E-03 | Pb-203 | 1.33E-02 |
| Ba-141 | 2.27E+00 | Er-171 | 9.22E-02 | Pb-210 | 3.55E-06 |
| Ba-142 | 3.88E+00 | Tm-170 | 2.25E-04 | Pb-212 | 6.51E-02 |
| La-140 | 1.72E-02 | Yb-169 | 9.03E-04 | Pb-214 | 1.55E+00 |
| La-142 | 4.35E-01 | Yb-175 | 6.89E-03 | Bi-206 | 4.63E-03 |
| Ce-139 | 2.10E-04 | Lu-177 | 4.30E-03 | Bi-207 | 2.37E-06 |
| Ce-141 | 8.88E-04 | Hf-181 | 6.81E-04 | Bi-214 | 2.09E+00 |
| Ce-143 | 2.10E-02 | Ta-182 | 2.52E-04 | Ra-226 | 4.94E-08 |
| Ce-144 | 1.02E-04 | Ta-183 | 5.78E-03 | Th-232 | 5.63E-15 |
| Pr-142 | 3.62E-02 | W-187 | 2.91E-02 | U-238 | 1.77E-14 |
| Pr-143 | 2.13E-03 | Re-188 | 4.08E-02 | Np-239 | 1.23E-02 |
| Pr-144 | 2.40E+00 | Os-191 | 1.88E-03 | Am-241 | 1.83E-07 |
| Nd-147 | 2.63E-03 | Ir-194 | 3.62E-02 | | |

λ_i = Radiological Decay Constant for nuclide i (hr^{-1})
= $0.693/T_i$

T_i = Radiological Half-Life in hours (from Reference 70 except for Cu-68, Tc-104, Ba-137, Ta-183, Tl-206, and Bi-206, which are from Reference 100).

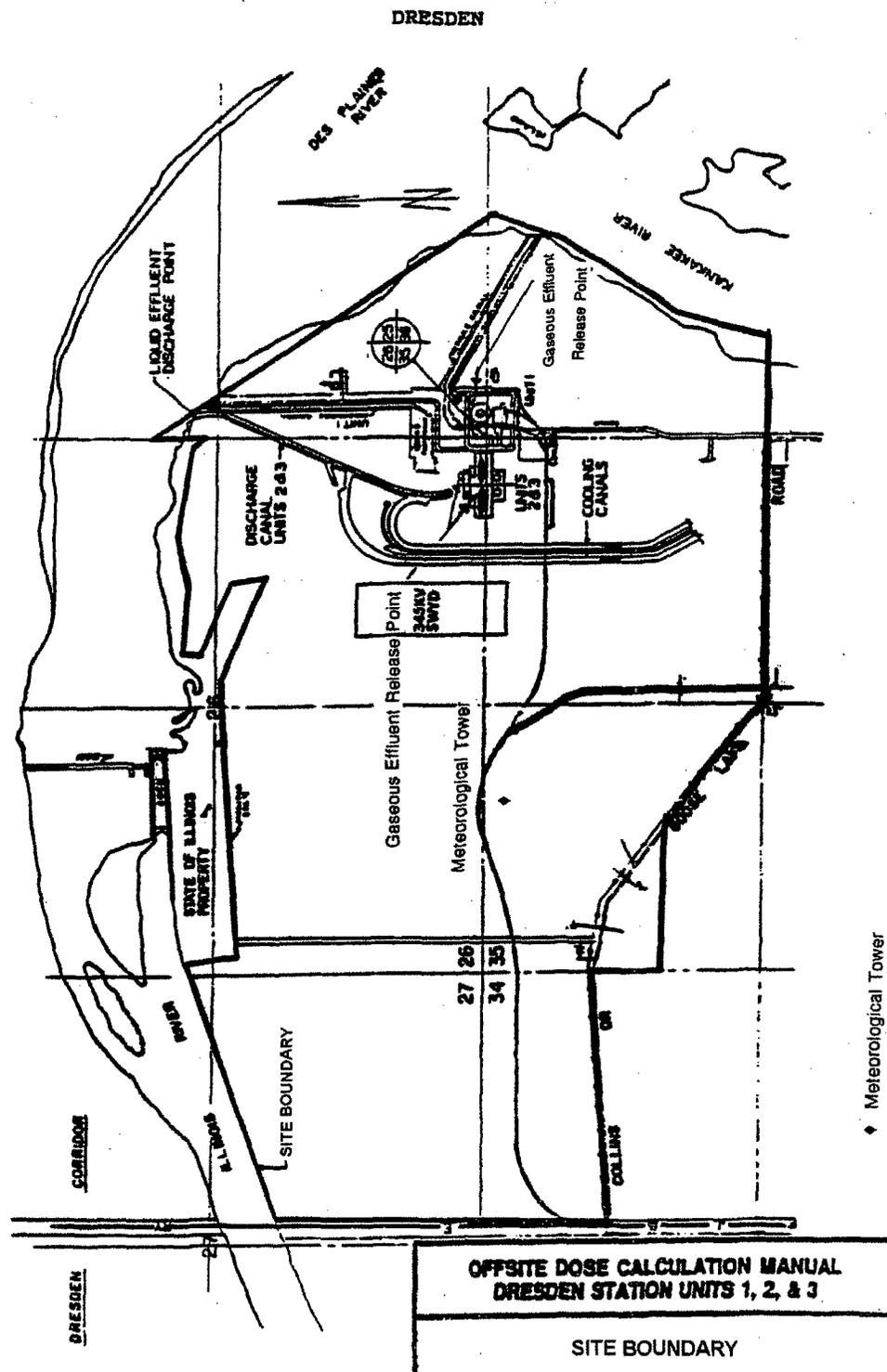


Figure 1-2
Site Boundary

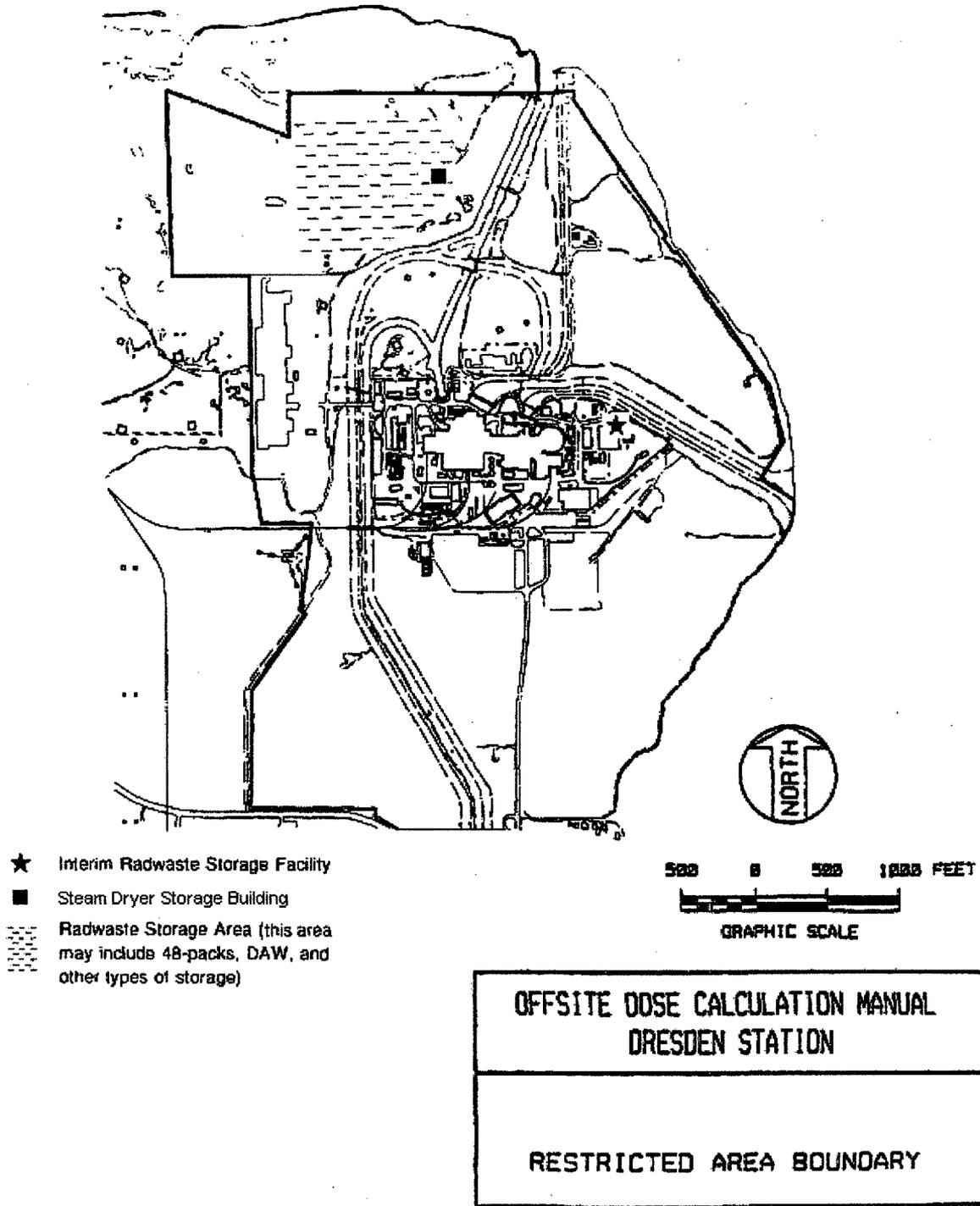


Figure 1-3
Restricted / Unrestricted Area Boundary

2.0 INSTRUMENTATION AND SYSTEMS

2.1 Liquid Effluents

2.1.1 Liquid Radwaste System Description

A simplified liquid radwaste and liquid effluent flow diagram is provided in Figure 2-1. The liquid radwaste treatment system is designed and installed to reduce radioactive liquid effluents by collecting the liquids, providing for retention or holdup, and providing for treatment by evaporator, demineralizer, filter, and further vendor processing systems for the purpose of reducing the total radioactivity prior to reuse or release to the environment. The system is described in the Dresden UFSAR Section 11.2.

2.1.1.1 Unit 1 Storage Tanks

Liquid radioactive effluents are not released from Unit 1 Storage tanks directly to the environment but are processed through the Units 2/3 Radwaste system.

2.1.1.2 Units 2/3 Waste Sample Tanks

There are three waste sample tanks (33,000 gallons each) that receive water from the liquid waste treatment system. These tanks are transferred to the waste surge tank for discharge to the Illinois River via the discharge canal.

2.1.1.3 Units 2/3 Floor Drain Sample Tanks

There are two floor drain sample tanks (22,000 gallons each) that receive liquid waste from the floor drain treatment system. These tanks are transferred to the waste surge tank or discharged to the Illinois River via the discharge canal.

2.1.1.4 Units 2/3 Waste Surge Tank

The waste surge tank (77,000 gallons) normally receives processed water from the waste sample tanks and floor drain sample tanks. The waste surge tank may also receive water from portable waste treatment system tanks. This tank discharges to the Illinois River via the discharge canal.

2.1.2 Radiation Monitors

Pertinent information on the monitor and associated control devices is provided in the Dresden UFSAR Section 11.5.

2.1.2.1 Units 2 & 3 Service Water Effluent Monitors

The monitors continuously monitor the service water effluent of each unit. No automatic functions are associated with the monitors. On high alarm a grab sample is taken.

2.1.2.2 Liquid Radwaste Effluent Monitor

The monitor is used to monitor releases from the waste surge tank, floor drain sample tanks or portable waste treatment system tanks. On high alarm, a grab sample of the effluent is automatically taken from the discharge side of the sample chamber after a 0 to 60 second delay determined by a locally mounted timer. The release is terminated manually by initiating closure of the low flow or high flow discharge line valves.

2.1.3 Liquid Radiation Effluent Monitors Alarm And Trip Setpoints

Alarm setpoints of liquid effluent monitors at the principal release points are established to ensure that the limits of 10CFR20 are not exceeded in the unrestricted area. The liquid effluent monitors do not have trip functions.

2.1.3.1 Liquid Radwaste Effluent Monitor

The monitor alarm setpoint is determined by solving equation 2-1 or set at 450,000 counts per minute; whichever is lower. The monitor detects only gamma-emitting radionuclides, so only gamma-emitting radionuclides are used in the setpoint calculation.

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$$P \leq K \times \frac{\sum_i c_{i\gamma}}{\sum_i (c_{i\gamma}/ECL_{i\gamma})} \times \frac{F+f}{f} \quad (2 - 1)$$

| | | |
|-----------------|--|----------------|
| where: | | (units) |
| P | Effluent monitor setpoint | [cpm] |
| K | Effluent monitor calibration constant | [cpm/(μCi/ml)] |
| $c_{i\gamma}$ | Concentration of gamma emitting radionuclide i in the release tank | [μCi/ml] |
| $ECL_{i\gamma}$ | Effluent Concentration Limit (ECL) for gamma-emitting radionuclide i. Also called Derived Water Concentration (DWC) or Maximum Permissible Concentration (MPC). Derived from 10CFR20, Appendix B, Table 2, Column 2. Ten (10) times the value of 10CFR20, Appendix B, Table 2, Column 2 for radionuclide i may be used per site Technical Specifications and REC 12.3.1. | [μCi/ml] |
| F | Dilution flow rate. The minimum dilution flow rate of 40,000 is used for setpoint calculations. | [gpm] |
| f | Flow rate from the radwaste discharge tank. The maximum pump discharge rate of 250 gpm is used for setpoint calculations. | [gpm] |

2.1.3.2 Units 2 & Unit 3 Service Water Effluent Monitors

The monitor setpoint is established at two times the background radiation value.

2.1.4 Discharge Flow Rates

Prior to each batch release, a grab sample is obtained. All detected and estimated (in the case of difficult to measure) nuclides are considered. The results of the sample analysis are used to determine the maximum permitted discharge rate of each batch as follows:

$$f_{\max} = 0.2 \times \frac{F}{\sum_i (c_i / ECL_i)} \quad (2 - 2)$$

| where: | (units) |
|--|----------------|
| f_{\max} Maximum discharge flow rate from the radwaste discharge tank. Releases are not permitted if the calculated discharge rate is less than 250 gpm. | [gpm] |
| 0.2 Reduction factor for conservatism. See 2.1.5. | |
| F Dilution flow rate. The minimum dilution flow rate of 40,000 is used for this calculation. | [gpm] |
| c_i Concentration of radionuclide i in the release tank based on measurements of a sample drawn from the tank and estimates of difficult-to-measure nuclide concentrations. | [μ Ci/ml] |
| ECL_i Effluent Concentration Limit (ECL) for radionuclide i. Also called Derived Water Concentration (DWC) or Maximum Permissible Concentration (MPC). Derived from 10CFR20, Appendix B, Table 2, Column 2. Ten (10) times 10CFR20, Appendix B, Table 2, Column 2 values may be used per site Technical Specifications and REC 12.3.1. | [μ Ci/ml] |

2.1.5 Release Limits

Release limits are determined from 10CFR20. Calculated maximum permissible discharge rates are divided by 5 to ensure that applicable effluent concentration limits are not exceeded.

2.1.5.1 Release Mixture

For the liquid radwaste effluent monitor, the release mixture used for the setpoint determination is the radionuclide mix identified in the grab sample gamma isotopic analysis.

For all other liquid effluent monitors, no release mixture is used because the setpoint is established at two times background.

2.1.5.2 Liquid Dilution Flow Rate

The dilution flow rate is determined using the installed flowmeter in the discharge canal.

2.1.5.3 Conversion Factors

The liquid radwaste effluent monitor and the Units 2 and 3 service water effluent monitors are standardized to a Cobalt-60 source to determine the calibration constant.

The readout for the liquid radwaste effluent monitor is in CPM.

The readouts for the Units 2 & 3 service water effluent monitors are in $\mu\text{Ci/ml}$.

2.1.6 Allocation of Effluents from Common Release Points

Radioactive liquid effluents released from the release tanks are comprised of contributions from all three units. Under normal operating conditions, it is difficult to apportion the radioactivity between the units. Consequently, allocation is normally made evenly between Units 2 and 3.

2.1.7 Projected Doses for Releases

Doses due to liquid effluents are calculated in accordance with the RECs.

2.2 Airborne Releases

2.2.1 System Description

A simplified gaseous radwaste and gaseous effluent flow diagram is provided for Dresden Unit 1 in Figure 2-2 and for Dresden Units 2 and 3 in Figure 2-3. Dresden 1 is no longer operational and all spent fuel is removed, but monitoring of potentially radioactive releases from the plant chimney continues.

Each airborne release point is classified as stack, vent, or ground level in accordance with the definitions in Section 4.1.4 and the results in Table 1.1-1 in Part I. The principal release points for potentially radioactive airborne effluents and their classifications are as follows:

- For Dresden 1:
 - The Unit 1 Main Chimney (a stack release point).
 - The Chemical Cleaning Building Ventilation (a vent release point)
- For Dresden 2/3:
 - The 2/3 Main Chimney (a stack release point).
 - The 2/3 Reactor Building Ventilation (a vent release point).

2.2.1.1 Condenser Offgas Treatment System

The condenser offgas treatment system is designed and installed to reduce radioactive gaseous effluents by collecting non-condensable off-gases from the condenser and providing for holdup to reduce the total radioactivity by decay prior to release to the environment. Charcoal and HEPA filters retain the daughter products. The system is described in Section 11.3 of the Dresden UFSAR.

2.2.1.2 Ventilation Exhaust Treatment System

Ventilation exhaust treatment systems are designed and installed to reduce gaseous radioiodine or radioactive material in particulate form in selected effluent streams by passing ventilation or vent exhaust gases through charcoal absorbers and/or HEPA filters prior to release to the environment. Such a system is not considered to have any effect on noble gas effluents. The ventilation exhaust treatment systems are shown in Figure 2-2 and Figure 2-3.

Engineered safety features atmospheric cleanup systems are not considered to be ventilation exhaust treatment system components.

2.2.2 Radiation Monitors

2.2.2.1 Unit 1 Chimney Sampler

Effluent from the chimney is sampled via an isokinetic probe. The sampler provides for continuous particulate and iodine sampling of the Unit 1 Chimney effluent.

This sampler performs no automatic isolation or control functions.

2.2.2.2 Units 2/3 Chimney Monitor

The 2/3 Chimney SPING continuously monitors the final effluent from the Units 2/3 Chimney.

Effluent from the chimney is sampled via an isokinetic probe. The monitor has continuous gaseous monitoring, continuous particulate and iodine sampling, and post accident sampling capability. A tap is available for obtaining other samples via the isokinetic probe, which is used for tritium sample collection or gaseous grab sample collection. There is a backup system, the Units 2/3 Chimney (GE) Radiation Monitor, consisting of two additional noble gas detectors and continuous particulate and iodine collection capability.

In normal operation the two lower SPING noble gas channels (low and mid-range) and the backup noble gas channels are on line and active. The high range noble gas channel flow is bypassed and this channel is in standby. At a predetermined threshold the low and mid-range noble gas channels are bypassed and only the high range noble gas channel remains active.

This monitor performs no automatic isolation or control functions. Further information is provided in Dresden UFSAR Section 11.5.

2.2.2.3 Reactor Building Ventilation Effluent Monitor

The 2/3 Reactor Building Vent SPING continuously monitors the final effluent from the 2/3 Reactor Building Vent stack.

Effluent from the chimney is sampled via an isokinetic probe. The monitor has continuous gaseous monitoring and continuous particulate and iodine sampling. A tap is available for obtaining other samples via the isokinetic probe, which is used for tritium sample collection or gaseous grab sample collection. Backup noble gas monitoring is performed using the Reactor Building Ventilation Duct Radiation Monitors, described below. Backup capability for continuous particulate and iodine sampling is available on both the Unit 2 and Unit 3 ventilation ducting.

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All channels are normally on line and active. This monitor performs no automatic isolation or control functions.

2.2.2.4 Reactor Building Ventilation Duct Radiation Monitors

Each monitor (located in the ventilation exhaust duct) monitors the effluent from the Unit 2 and Unit 3 reactor building ventilation. On high alarm, the monitors automatically initiate isolation of the Unit 2(3) reactor building ventilation, and initiate startup of the Unit 2/3 Standby Gas Treatment System.

Further information is provided in Dresden UFSAR Section 11.5.

2.2.2.5 Condenser Air Ejector Monitors

The monitors continuously monitor gross gamma activity downstream of the Unit 2 and Unit 3 steam jet air ejector prior to release to the 2/3 Main Chimney.

At the trip setpoint the monitors automatically activate an interval timer that in turn initiates closure of an air-operated valve, thus terminating the release.

Further information is provided in Dresden UFSAR Section 11.5.

2.2.2.6 Isolation Condenser Vent Monitor

The monitor continuously monitors radioactivity in the effluent from the isolation condenser vent to provide indication of a tube leak. This monitor initiates no control device.

Further information is provided in Dresden UFSAR Section 11.5.

2.2.2.7 Chemical Cleaning Building Ventilation Sampler

The sampler provides for continuous particulate and iodine sampling of the Chemical Cleaning Building effluent.

This monitor performs no automatic isolation, control functions or alarm functions.

2.2.3 Gaseous Radiation Effluent Monitors Alarm and Trip Setpoints

2.2.3.1 Reactor Building Vent (Duct) Monitors

The alarm setpoint for the Reactor Building Vent monitors is set at ≤ 10 mr/hr.

2.2.3.2 Condenser Air Ejector Monitors

The high-high trip limit is established at ≤ 100 $\mu\text{Ci}/\text{sec}$ per MWt (252,700 $\mu\text{Ci}/\text{sec}$). The high alarm is set at 1.5 times the normal full power background with hydrogen addition to satisfy licensing commitments associated with the main steam line monitor Technical Specification amendments.

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2.2.3.3 Units 2/3 Chimney (GE) Radiation Monitor

The setpoint is established at a count rate corresponding to no greater than 105,000 $\mu\text{Ci}/\text{sec}$.

2.2.4 Release Limits

Alarm and trip setpoints of gaseous effluent monitors are established to ensure that the release rate limits of RECs are not exceeded. The release rate limit requirements are met when Equations 2-3 and 2-4 are satisfied:

$$1.11 \times \sum_i \left(f_i (\dot{Q}_{ts} \bar{S}_i + \dot{Q}_{tv} \bar{V}_i) \right) < 500 \text{ mrem / yr} \quad (2-3)$$

$$\sum_i \left(L_i f_i \left(\left(\frac{\chi}{Q} \right)_s \dot{Q}_{ts} e^{\frac{-\lambda_i R}{3600 u_s}} + \left(\frac{\chi}{Q} \right)_v \dot{Q}_{tv} e^{\frac{-\lambda_i R}{3600 u_v}} \right) + (1.11 \times f_i (\dot{Q}_{ts} S_i + \dot{Q}_{tv} V_i)) \right) < 3000 \text{ mrem / yr} \quad (2-4)$$

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where:

1.11 Conversion factor to rem in tissue from rads in air. (units) [mrem/mrad]

f_i Fractional Radionuclide Composition. The release rate of noble gas radionuclide i divided by the total release rate of all noble gas radionuclides, dimensionless.

\dot{Q}_{ts} Total allowed Release Rate, Stack Release. The total allowed release rate of all noble gas radionuclides released as stack releases. [$\mu\text{Ci}/\text{sec}$]

\dot{Q}_{tv} Total Allowed Release Rate, Vent Release. The total allowed release rate of all noble gas radionuclides released as vent releases. Limited by the Unit 2 and Unit 3 Reactor Building Duct Radiation Monitors' setpoint (≤ 10 mrem). [$\mu\text{Ci}/\text{sec}$]

Remaining terms are defined in Section II, Part 4.

Equation 2-3 is based on Equation 4-1 and the RECs restriction on total body dose rate (500 mrem/yr) due to noble gases released in gaseous effluents (see Section 4.2.1.2). Equation 2-4 is based on Equation 4-2 and the RECs restriction on skin dose rate (3000 mrem/yr) due to noble gases released in gaseous effluents (see Section 4.2.1.3).

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Calibration methods and surveillance frequency for the monitors are conducted as specified in the RECs.

2.2.4.1 Release Mixture

In the determination of alarm and trip setpoints the radioactivity mixture in the exhaust air is assumed to have the following compositions.

- Reactor Building Vent (Duct) Monitors

The mixture used for the duct monitors is taken from a representative isotopic analysis of the vent stack noble gas released since the last calibration, or based on nominal response of detector. The "mixture" used for the SPING is assumed to be a single pseudo-noble gas radionuclide.

- Condenser Air Ejector Monitors

The mixture used for this monitor is taken from a representative isotopic analysis of noble gases collected at the recombiner outlet during plant operation, since the last alarm setpoint calculation.

- Units 2/3 Chimney Monitors

The mixture used for the GE monitors is taken from the most recent isotopic analysis of noble gases collected from the chimney monitor that corresponds to an above background recorder reading. The "mixture" used for the SPING is assumed to be a single pseudo-noble gas radionuclide.

2.2.4.2 Conversion Factors

The conversion factors used to establish gaseous effluent monitor setpoints are obtained as follows.

- Reactor building vent effluent monitors

For the duct monitors, the isotopic analysis in Section 2.2.4.1 and the monitor reading (in mR/hr) at the time of the analysis are used to establish the conversion factor in mR/hr per $\mu\text{Ci/cc}$ or $\mu\text{Ci/ft}^3$ or nominal response of the detector (7200 mR/hr per $\mu\text{Ci/sec}$ at design flow rate) is used. For the SPING the conversion factor is based on the 0.8 MeV gamma of the pseudo-noble gas radionuclide.

- Condenser air ejector monitor

The isotopic analysis in Section 2.2.4.1 and the flow and monitor reading (in mR/hr) at the time of the analysis are used to establish the conversion factor in mR/hr per $\mu\text{Ci/cc}$ or $\mu\text{Ci/ft}^3$.

- Units 2/3 plant chimney monitors

For the GE monitors, the isotopic analysis in Section 2.2.4.1 and flow and monitor reading (in cps) at the time of the analysis are used to establish the conversion factor in cps per $\mu\text{Ci/cc}$ or $\mu\text{Ci/ft}^3$. For the SPING the conversion factor is based on the 0.8 MeV gamma of the pseudo-noble gas radionuclide.

2.2.4.3 HVAC Flow Rates to determine release limits

The HVAC exhaust flow rates are obtained from either the Units 2/3 process computers or the SPING control station. For the 2/3 Chimney, additional process flow rates must be added to obtain the total chimney flow (see Figure 2-3). Unit operation may affect actual flow rates, which therefore may differ from values listed. If the actual flows are not available, the following default values based on design flow can be used:

| | |
|--|----------------|
| Units 2/3 Chimney Air Flow | 1.25E10 cc/min |
| Unit 2 and Unit 3 Reactor Building Vent (each) | 3.11E9 cc/min |
| Units 2/3 Combined Reactor Building Vent | 6.23E9 cc/min |
| Unit 1 Chimney Air Flow | 8.41E8 cc/min |
| Unit 1 Chemical Cleaning Chimney Air Flow | 1.61E9 cc/min |

2.2.5 Allocation of Effluents from Common Release Points

Radioactive particulates and iodine released from the Unit 1 Chemical Cleaning Chimney originate from the Chemical Cleaning Building and Interim Radwaste Storage Facility.

Radioactive gases, particulates, and iodines released from the Unit 1 Chimney originate from Unit 1 only. However, radioactive gaseous effluents released from Units 2/3 are comprised of contributions from both units. Estimates of noble gas contributions from Units 2 and 3 are allocated considering appropriate operating conditions and measured SJAE off-gas activities. Allocation of radioiodine and radioactive particulate releases to Units 2 or 3 specifically is not as practical and is influenced greatly by in-plant leakage. Under normal operating conditions, allocation is made using reactor coolant iodine activities. During unit shutdowns or periods of known major in-plant leakage, the apportionment is adjusted accordingly. The allocation of effluents is estimated on a monthly basis.

2.2.6 Dose Projections

Because radioactive gaseous releases are continuous, dose estimates and projections are routinely calculated in accordance with the RECs.

2.3 Solidification Of Waste/Process Control Program

The process control program (PCP) contains the sampling, analysis, and formulation determination by which solidification of radioactive wastes from liquid systems is ensured.

Figure 2-4 is a simplified diagram of solid radwaste processing.

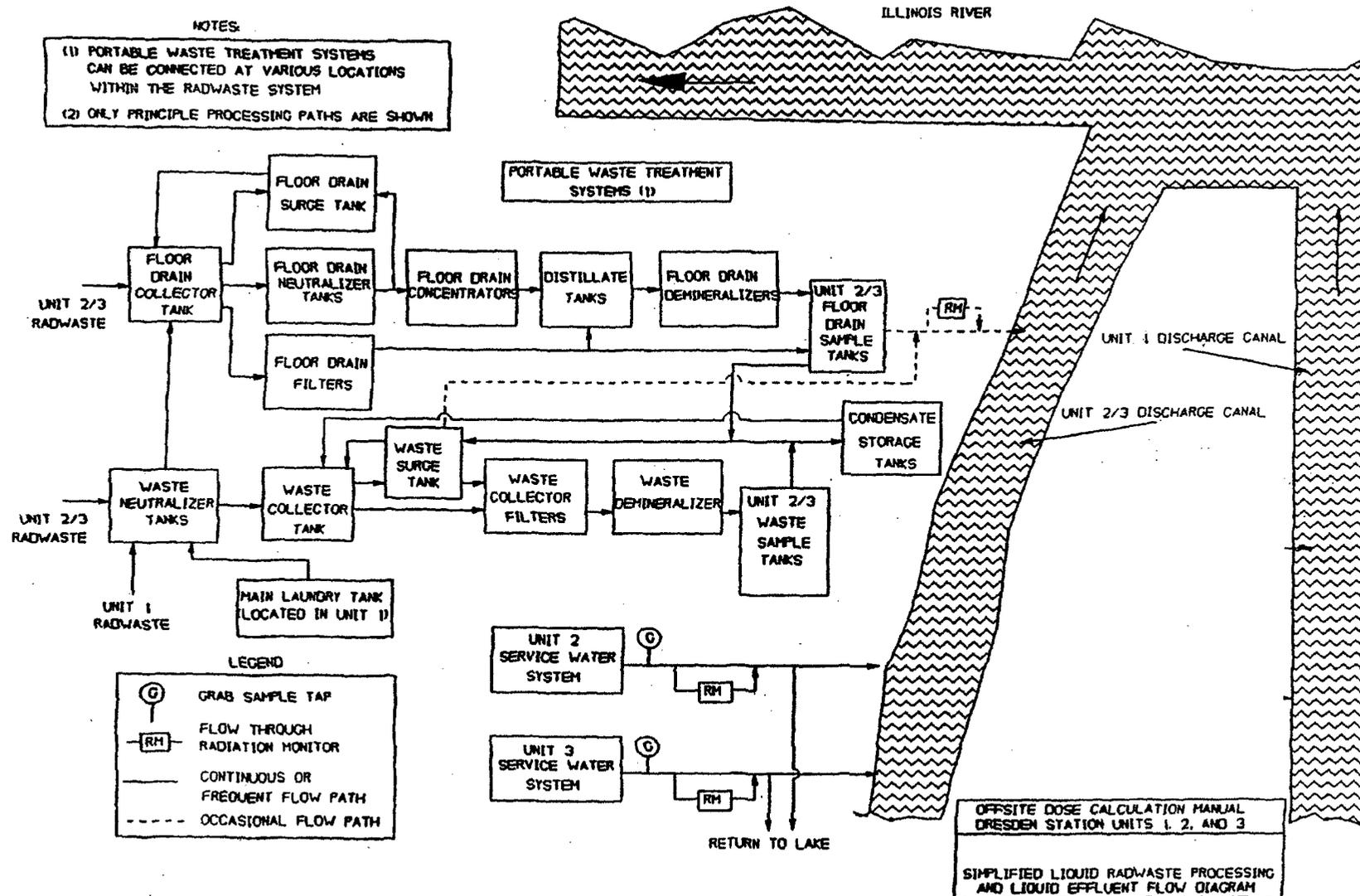
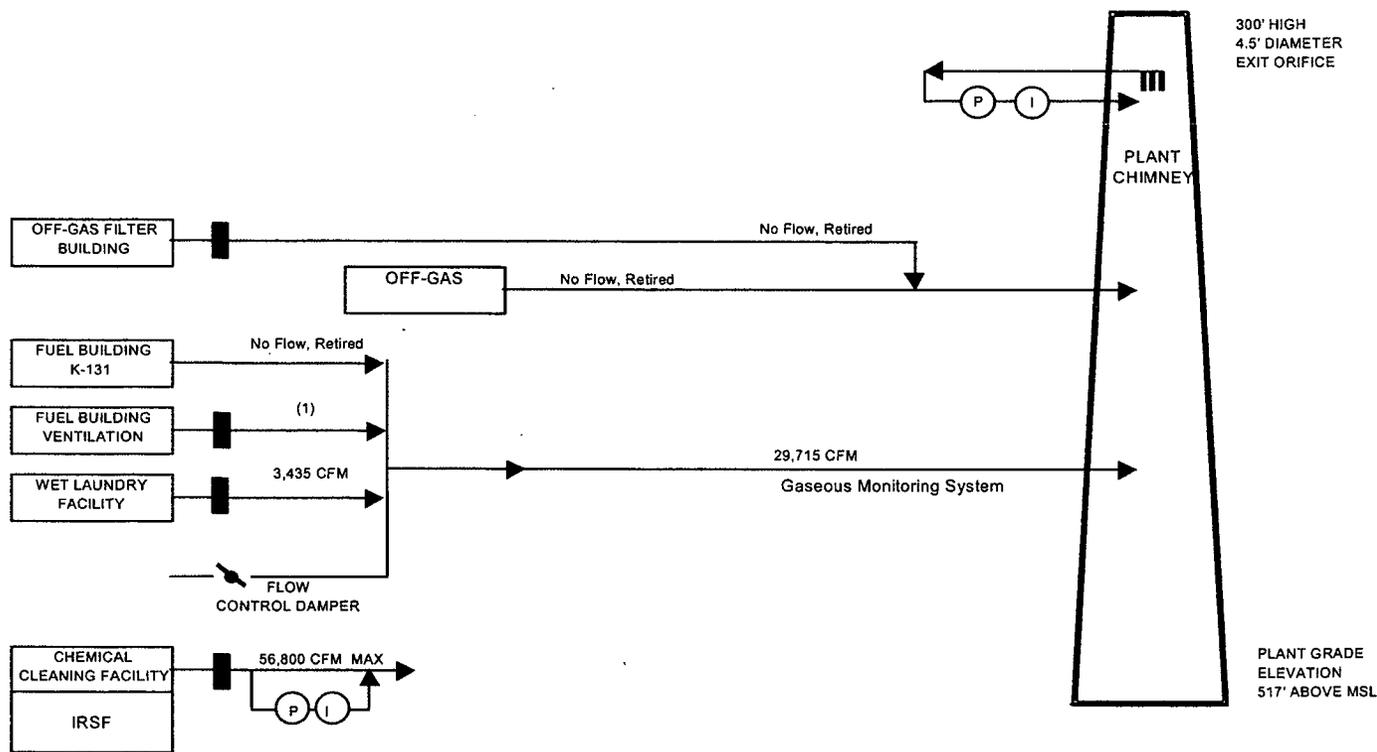


Figure 2-1



(1) 8,000 CFM summer
 4,000 CFM winter

| LEGEND AND NOTES | |
|---|--------------------|
| | HEPA FILTER |
| | PARTICULATE SAMPLE |
| | IODINE SAMPLE |
| NOTES: | |
| 1. UNIT 1 IS NOT OPERATIONAL | |
| 2. ALL FLOW RATES ARE DESIGN FLOW RATES, NOT ACTUAL | |

| |
|--|
| OFFSITE DOSE CALCULATION MANUAL DRESDEN STATION UNIT 1 |
| SIMPLIFIED GASEOUS RADWASTE AND GASEOUS EFFLUENT FLOW DIAGRAM |

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Figure 2-2

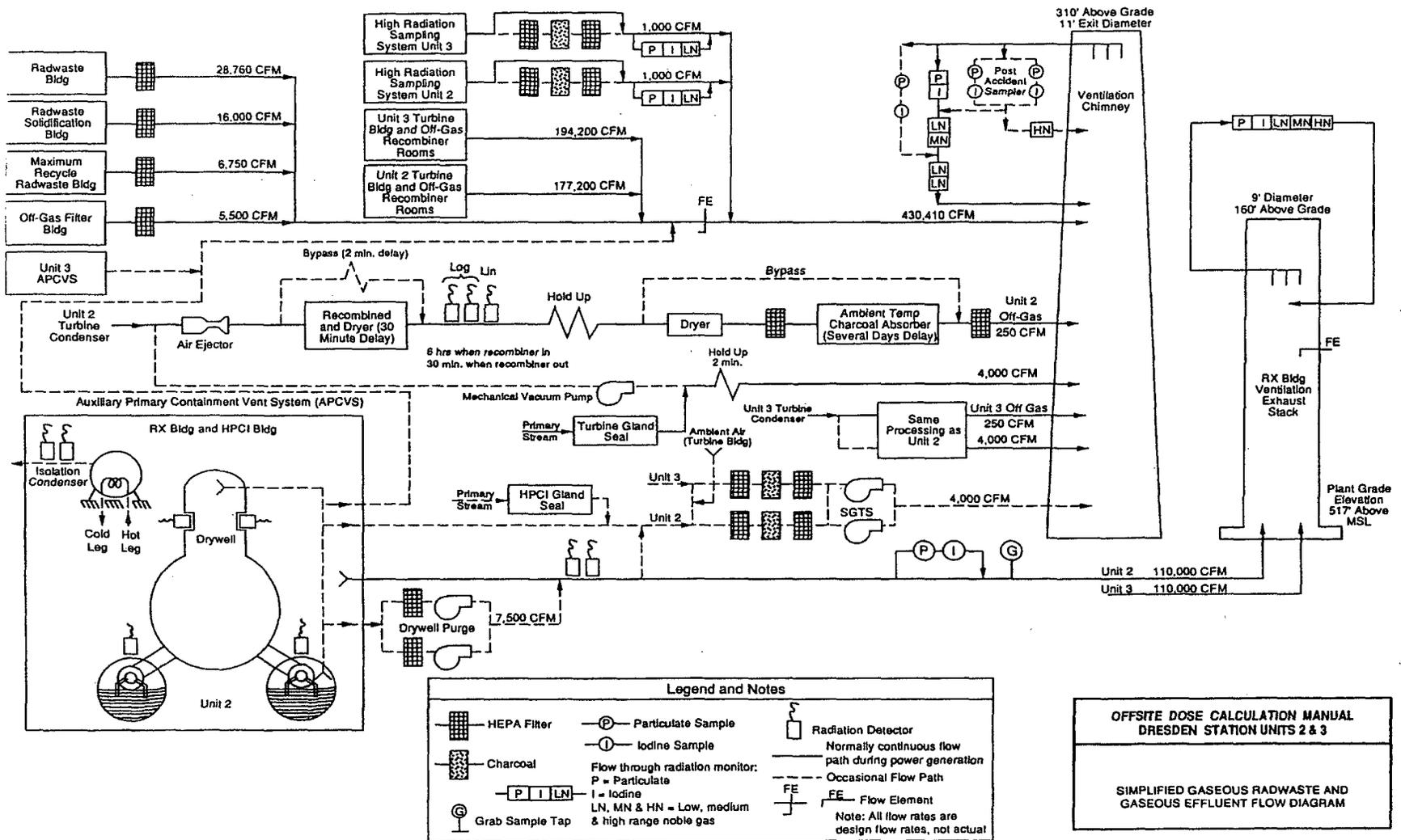


Figure 2-3

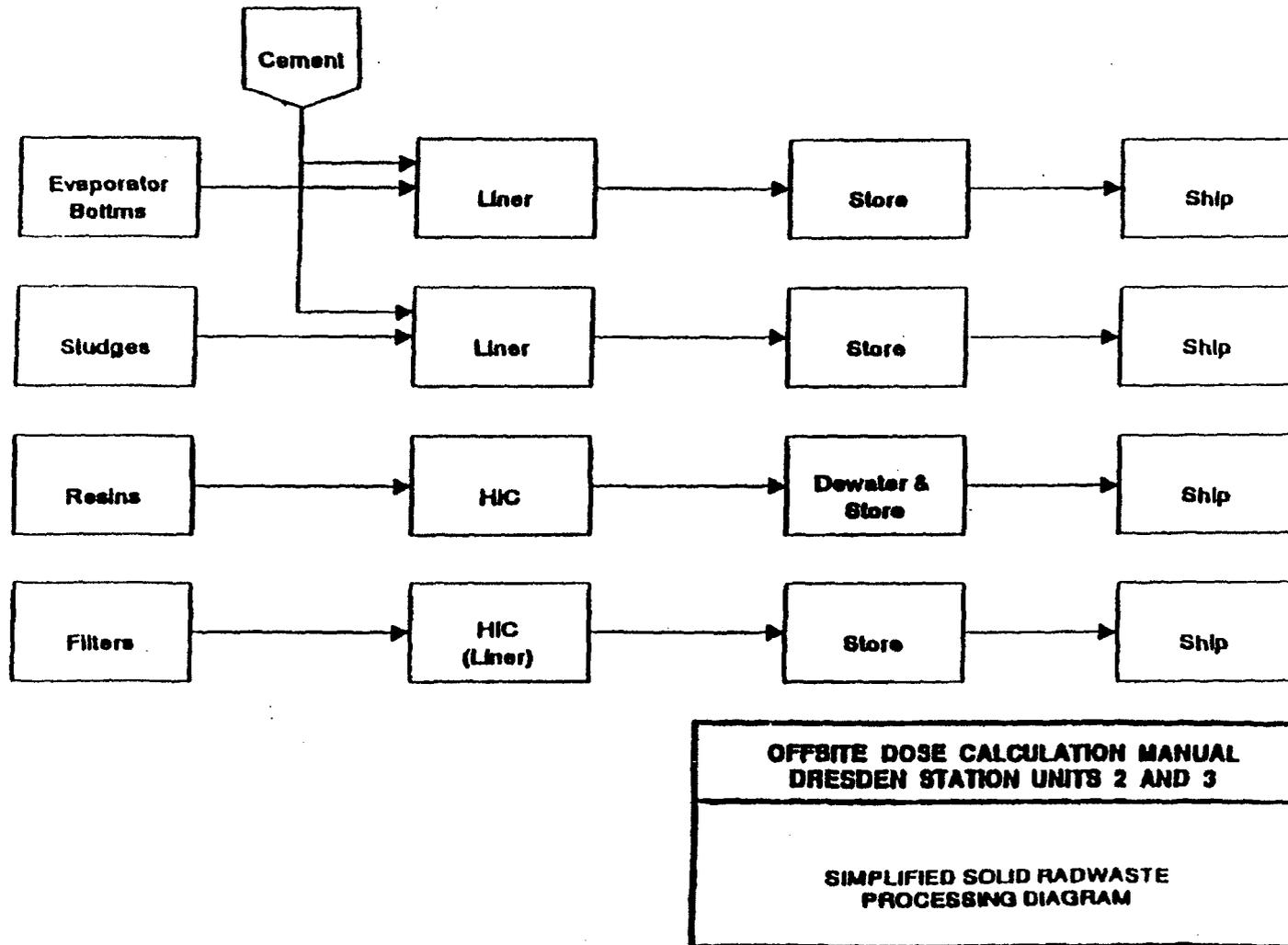


Figure 2-4

3.0 LIQUID EFFLUENTS

3.1 Liquid Effluent Releases – General Information

- 3.1.1 The design objectives of 10CFR50, Appendix I and RECS provide the following limits on the dose or dose commitment to a member of the public from radioactive materials in liquid effluents released from each reactor unit to restricted area boundaries:
- During any calendar quarter, less than or equal to 1.5 mrem to the total body and less than or equal to 5 mrem to any organ.
 - During any calendar year, less than or equal to 3 mrem to the total body and less than or equal to 10 mrem to any organ.
- 3.1.2 The organ doses due to radioactivity in liquid effluents are also used as part of the 40CFR190 compliance and are included in the combination of doses to determine the total dose used to demonstrate 10CFR20 compliance. (See Section 5.0, Total Dose)
- 3.1.3 Dose assessments for 10CFR20 and 40CFR190 compliance are made for an adult using Federal Guidance Report No. 11 (Reference 93) dose conversion factors. Dose assessments for 10CFR50 Appendix I compliance are made for four age groups (adult, teenager, child, infant) using Regulatory Guide 1.109 (Reference 6) dose conversion factors.
- 3.1.4 To limit the consequences of tank overflow, the Technical Specifications / Technical Requirements Manual (TRM) limits the quantity of radioactivity that may be stored in unprotected outdoor tanks. Unprotected tanks are tanks that are not surrounded by liners, dikes, or walls capable of holding the tank contents and that do not have tank overflows and surrounding area drains connected to the liquid radwaste treatment system. The specific objective is to provide assurance that in the event of an uncontrolled release of a tank's contents, the resulting radioactivity concentrations beyond the unrestricted area boundary, at the nearest potable water supply and at the nearest surface water supply, will be less than the limits of 10CFR20 Appendix B, Table 2; Column 2.
- 3.1.5 Cases in which normally non-radioactive liquid streams (such as the Service Water) are found to contain radioactive material are non-routine will be treated on a case specific basis if and when this occurs. Since the station has sufficient capacity to delay a liquid release for reasonable periods of time, it is expected that planned releases will not take place under these circumstances. Therefore, the liquid release setpoint calculations need not and do not contain provisions for treating multiple simultaneous release pathways.

3.2 Liquid Effluent Concentrations

3.2.1 As a means of assuring that annual concentration limits will not be exceeded, and as a matter of policy assuring that doses by the liquid pathway will be ALARA; RECS provides the following restriction:

"The maximum concentration of radioactive material released in liquid effluents to UNRESTRICTED AREAS (see Part II Figure 1-3) shall be limited to 10 times the concentration specified in 10 CFR 20 Appendix B, Table 2, Column 2 for radionuclides other than dissolved or entrained noble gases and 2×10^{-4} microCurie/ml total activity for all dissolved or entrained noble gases."

3.2.2 An alternate method of demonstrating compliance to the requirements of 10CFR20.1301 is to demonstrate that the annual average concentrations of radioactive material released in gaseous and liquid effluents do not exceed the values specified in 10CFR20 Appendix B, Table 2, Column 2. (See 10CFR 20.1302(b)(2).) However, as noted in Section 5.5.1, this alternate method of 10CFR20.1301 compliance is not used.

3.2.3 Liquid effluents concentrations are controlled as described in Part II, Section 2.1.

3.2.4 When radioactivity is released to the unrestricted area with liquid discharge from a tank (e.g., a radwaste discharge tank), the concentration of a radionuclide in the effluent at the unrestricted area boundary is calculated as follows:

$$C_i = c_i \frac{f}{F + f} \quad (3-1)$$

| | | |
|--------|---|----------------|
| where: | | (units) |
| C_i | Concentration of radionuclide i in liquid released to the unrestricted area (after initial dilution). | [μ Ci/ml] |
| c_i | Concentration of radionuclide i in the discharge tank (undiluted). | [μ Ci/ml] |
| f | Flow rate, tank discharge | [gpm] |
| F | Flow rate, initial dilution stream | [gpm] |

3.2.5 When a radionuclide mix of known composition is released, the concentrations released to the unrestricted area must be such that:

$$\sum_i \left(\frac{C_i}{ECL_i} \right) \leq 1 \quad (3-2)$$

| | | |
|---------|---|------------------------------|
| where: | | (units) |
| C_i | Concentration of radionuclide i in liquid released to the unrestricted area (after initial dilution). | [$\mu\text{Ci}/\text{ml}$] |
| ECL_i | Effluent Concentration Limit (ECL) for radionuclide i . Also called Derived Water Concentration (DWC) or Maximum Permissible Concentration (MPC). Derived from 10CFR20, Appendix B, Table 2, Column 2. Ten (10) times 10CFR20, Appendix B, Table 2, Column 2 values may be used per site Technical Specifications and REC 12.3.1. | [$\mu\text{Ci}/\text{ml}$] |

If either the identity or concentration of any radionuclide in the mixture is not known, special rules apply. These are given in the footnotes in 10CFR20 Appendix B, Table 2, Column 2.

3.2.6 The RECs and Technical Specifications require a specified sampling and analysis program to assure that liquid radioactivity concentrations at the point of release are maintained within the required limits. To comply with this provision, samples are analyzed in accordance with the Radioactive Liquid Waste Sampling and Analysis Program in Section 12.3.1 of Part I, RECs.

3.3 Liquid Effluent Dose Calculation Requirements

3.3.1 RECs require determination of cumulative and projected dose contributions from liquid effluents at least once per 31 days. (See Section 12.3.2 of Part I, RECS.)

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3.3.2 Radioactive liquid effluents released from the release tanks are comprised of contributions primarily from Units 2 and 3. Contributions from Unit 1 are negligible. Under normal operating conditions, it is difficult to apportion the radioactivity between the units. Consequently, allocation is normally made evenly between Units 2 and 3.

3.3.3 Functionality and Use of the Liquid Radwaste Treatment System

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The design objectives of 10CFR50, Appendix I and RECs/Technical Specifications require that the liquid radwaste treatment system be FUNCTIONAL and that appropriate portions be used to reduce releases of radioactivity when projected doses due to the liquid effluent from each reactor unit to unrestricted areas exceed either of the following (see Section 12.3.3 of Part I, RECS):

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- 0.06 mrem to the total body in a 31-day period.
- 0.2 mrem to any organ in a 31-day period.

3.4 Dose Methodology

3.4.1 Liquid Effluent Dose Method: General

The dose commitment from radioactive materials in liquid effluents is calculated for the four age groups considering only the two principle pathways for radiation exposure. The dose commitment to each organ and to the total body is obtained as the sum of contributions from consumption of drinking water and fish:

$$D_{ja}^{liq} = D_{ja}^{water} + D_{ja}^{fish} \quad (3-3)$$

where:

$$D_{ja}^{water} = (1.1E-3)(8760) \left(\frac{U_a^w M^w}{F^w} \right) \times \sum_i (C_i D F I_{ija} e^{-\lambda_i t^w}) \quad (3-4)$$

$$D_{ja}^{fish} = (1.1E-3)(8760) \left(\frac{U_a^f M^f}{F^f} \right) \times \sum_i (C_i B_i D F I_{ija} e^{-\lambda_i t^f}) \quad (3-5)$$

| | | |
|------------------|---|---|
| and: | | (units) |
| D_{ja}^{liq} | Total organ and total body dose commitment (CDE) due to Radioactivity in Liquid Effluents. Dose commitment to organ j and total body of age group a consuming water and fish containing radioactivity released in liquid effluents. | [mrem] |
| D_{ja}^{water} | Committed Dose Equivalent (CDE) due to Consumption of Drinking Water. Dose commitment to organ j and total body of age group a consuming water containing radioactivity released in liquid effluents. | [mrem] |
| D_{ja}^{fish} | Committed Dose Equivalent (CDE) due to Consumption of Fish. Dose commitment to organ j and total body of age group a consuming fish containing radioactivity released in liquid effluents. | [mrem] |
| 1.1E-3 | Conversion constant to pCi/L from μ Ci/yr per cfs. | $\left[\frac{(\text{pCi/L})(\text{cfs})}{\mu\text{Ci/yr}} \right]$ |
| 8760 | Conversion constant to hours from years | [hr/yr] |
| U_a^w, U_a^f | Usage Factor. Consumption rate of water (^w) or fish (^f). See Table 1-5. | [L/hr(^w) or kg/hr(^f)] |
| M^w, M^f | Mixing ratio (reciprocal of dilution factor) at the point of exposure, prior to withdrawing water or fish. See Table 3-2. | |
| F^w | Average Flow Rate of receiving body of water at point where potable water is taken. See Table 3-2. | [cfs] |
| F^f | Near-Field Flow Rate of receiving body of water in region where fish are taken. See Table 3-2. | [cfs] |
| C_i | Radionuclide Release. Amount of radionuclide i released in liquid effluents during the time period under consideration. | [μ Ci] |

| B_i | Bioaccumulation Factor. Equilibrium ratio of the concentration of radionuclide i in fish (pCi/kg) to its concentration in water (pCi/L). See Table 3-3. | [L/kg] | | | | | | | | | |
|--------------------|--|---------------------|--------------------|------------------|----------------|--|------------|--------------------|--|-----------------|--|
| DF_{ija} | Ingestion Dose Factor. Dose commitment to organ j and total body of an individual in age group a per unit of radionuclide i ingested. | [mrem/pCi] | | | | | | | | | |
| | <table border="0"> <thead> <tr> <th style="text-align: left;"><u>Assessment</u></th> <th style="text-align: left;"><u>Dose Factor</u></th> <th style="text-align: left;"><u>Age Group</u></th> </tr> </thead> <tbody> <tr> <td>10CFR50 App. I</td> <td>Reg. Guide 1.109 Tables E-11 – E-14</td> <td>All (four)</td> </tr> <tr> <td>10CFR20 / 40CFR190</td> <td>Federal Guidance Report No. 11, Table 2.2</td> <td>Adult (average)</td> </tr> </tbody> </table> | <u>Assessment</u> | <u>Dose Factor</u> | <u>Age Group</u> | 10CFR50 App. I | Reg. Guide 1.109 Tables E-11 – E-14 | All (four) | 10CFR20 / 40CFR190 | Federal Guidance Report No. 11, Table 2.2 | Adult (average) | |
| <u>Assessment</u> | <u>Dose Factor</u> | <u>Age Group</u> | | | | | | | | | |
| 10CFR50 App. I | Reg. Guide 1.109 Tables E-11 – E-14 | All (four) | | | | | | | | | |
| 10CFR20 / 40CFR190 | Federal Guidance Report No. 11, Table 2.2 | Adult (average) | | | | | | | | | |
| λ_i | Radiological decay constant of radionuclide i . See Table 1-6. | [hr ⁻¹] | | | | | | | | | |
| t^w, t^f | Elapsed time between release and consumption of water (^w) or fish (^f). See Table 3-2. | [hr] | | | | | | | | | |

Offsite doses due to projected releases of radioactive materials in liquid effluents are calculated using Equation 3-3. Projected radionuclide release concentrations are used in place of measured concentrations, C_i .

3.4.2 Dose due to Drinking Water (40CFR141)

The National Primary Drinking Water Regulations, 40CFR141, contain the requirements of the Environmental Protection Agency applicable to public water systems. Included are limits on radioactivity concentration. Although these regulations are directed at the owners and operators of public water systems, Dresden has requirements in the RECs related to 40CFR141. Peoria, located 106 miles downriver of the station, is nearest community water system that can be affected by station liquid effluents.

3.4.2.1 40CFR141 Restrictions on Manmade Radionuclides

Section 141.16 states the following:

- (a) The average annual concentration of beta particle and photon radioactivity from man-made radionuclides in drinking water shall not produce an annual dose equivalent to the total body or any internal organ greater than 4 millirem/year.
- (b) Except for the radionuclides listed in Table 3-1, the concentration of man-made radionuclides causing 4 mrem total body or organ dose equivalents shall be calculated on the basis of drinking 2 liter of water per day (using the 168 hour data listed in "Maximum Permissible Body Burdens and Maximum Permissible Concentration of Radionuclides in Air or Water for Occupational Exposure," NBS Handbook 69 as amended August 1963, U.S. Department of Commerce). If two or

more radionuclides are present, the sum of their annual dose equivalents to the total body or any organ shall not exceed 4 millirem/year.

Table 3-1
Average Annual Concentrations Assumed to
Produce a Total Body or Organ Dose of 4 mrem/yr

| Radionuclide | Critical Organ | pCi/liter |
|---------------------|-----------------------|------------------|
| Tritium | Total body | 20,000 |
| Strontium-90 | Bone marrow | 8 |

3.4.2.2 Application

The projection or calculation of dose due to the drinking water pathway is made using Equation 3-4. Projections are made using projected radionuclides releases in place of measured releases C_i . Doses calculated using Equation 3-4 may differ from doses determined by the methodology prescribed in 40CFR141.16.

When required, Dresden prepares a special report on radiological impact at the nearest community water system. The report should include the following:

- The doses calculated by Equation 3-4.
- A statement identifying the dose calculation methodology (e.g., a reference to this manual).
- A statement that the doses calculated by the ODCM methodology are not necessarily the same as doses calculated by the methodology prescribed in 40CFR141.16.
- The data used to calculate the doses. This information includes the amounts of radioactivity released and the flow rate and dilution values used (see Table 3-2). This information is provided to assist the operator of the community water system in performing its own dose assessment.

3.5 Aquatic Environmental Dose Parameters, General Information

- 3.5.1 This information is based on Figure 2.2.6-1 of the Dresden UFSAR (update through Rev. 5, June 1987), Section 2.4.1.1 and Figure 2.4-2 of the LaSalle Environmental Report, and the Dresden SAR, Section 2.5, Dresden Station Water Flow Schematic, and Braidwood and LaSalle Stations' collective data.
- 3.5.2 The station liquid discharge flows into the Illinois River. The nearest public potable water intake is at Peoria, 106 miles downstream of the station.
- 3.5.3 There is no irrigation occurring on the Illinois River downstream of the station.
- 3.5.4 Recreation includes one or more of the following: boating, water-skiing, swimming, and sport fishing.
- 3.5.5 Downstream dams on the Illinois River within 50 miles of the station are located at:
- Dresden Island
 - Marseilles
 - Starved Rock
- 3.5.6 Information on radioactivity limits in unprotected outdoor tanks can be found in the Units 2 and 3 Technical Specifications, Section 5.5.8.

Table 3-2
Miscellaneous Dose Assessment Factors: Water and Fish Ingestion Parameters

| Parameter | Value | Description | Units |
|-----------|----------|--|-------|
| t^w | 106.0 | Elapsed time between release and consumption of water. (Illinois River flow rate of 1 mph assumed) | [hr] |
| t^f | 24.0 | Elapsed time between release and consumption of fish. | [hr] |
| M^f | 1.0 | Mixing ratio (reciprocal of dilution factor) at the point of exposure, prior to withdrawing fish. | - |
| M^w | 1.0 | Mixing ratio (reciprocal of dilution factor) at the point of exposure, prior to withdrawing water. | - |
| F^w | 1.85E+04 | Average Flow Rate of receiving body of water at point where potable water is taken. | [cfs] |
| F^f | 1.04E+04 | Near-Field Flow Rate of receiving body of water in region where fish are taken. | [cfs] |

Table 3-3
Bioaccumulation Factors (B_i)

| Element | B_i for Freshwater Fish (pCi/kg per pCi/L) | Reference | Element | B_i for Freshwater Fish (pCi/kg per pCi/L) | Reference |
|---------|--|-------------|---------|--|-------------|
| H | 9.0E-01 | 6 | In | 2.2E+03 | Footnote 13 |
| Be | 2.8E+01 | Footnote 2 | Sn | 2.4E+03 | Footnote 12 |
| C | 4.6E+03 | 6 | Sb | 1.0E+00 | 98 |
| F | 2.2E+02 | Footnote 16 | Ag | 2.3E+00 | 56 |
| Na | 1.0E+02 | 6 | Te | 4.0E+02 | 6 |
| Mg | 2.8E+01 | Footnote 2 | I | 1.5E+01 | 6 |
| Al | 2.2E+03 | Footnote 13 | Xe | NA | NA |
| P | 1.0E+05 | 6 | Cs | 2.0E+03 | 6 |
| Cl | 2.2E+02 | Footnote 16 | Ba | 4.0E+00 | 6 |
| Ar | NA | NA | La | 2.5E+01 | 6 |
| K | 1.0E+03 | Footnote 1 | Ce | 1.0E+00 | 6 |
| Ca | 2.8E+01 | Footnote 2 | Pr | 2.5E+01 | 6 |
| Sc | 2.5E+01 | Footnote 3 | Nd | 2.5E+01 | 6 |
| Ti | 3.3E+00 | Footnote 4 | Pm | 3.0E+01 | 98 |
| V | 3.0E+04 | Footnote 5 | Sm | 3.0E+01 | Footnote 3 |
| Cr | 2.0E+02 | 6 | Eu | 1.0E+02 | Footnote 3 |
| Mn | 4.0E+02 | 6 | Gd | 2.6E+01 | Footnote 3 |
| Fe | 1.0E+02 | 6 | Dy | 2.2E+03 | Footnote 3 |
| Co | 5.0E+01 | 6 | Er | 3.3E+04 | Footnote 3 |
| Ni | 1.0E+02 | 6 | Tm | 4.0E+02 | Footnote 3 |
| Cu | 5.0E+01 | 6 | Yb | 2.2E+02 | Footnote 3 |
| Zn | 2.0E+03 | 6 | Lu | 2.5E+01 | Footnote 3 |
| Ga | 2.2E+03 | Footnote 13 | Hf | 3.3E+00 | Footnote 4 |
| Ge | 2.4E+03 | Footnote 12 | Ta | 3.0E+04 | Footnote 5 |
| As | 3.3E+04 | Footnote 14 | W | 1.2E+03 | 6 |
| Se | 4.0E+02 | Footnote 15 | Re | 2.1E+02 | Footnote 6 |
| Br | 4.2E+02 | 6 | Os | 5.5E+01 | Footnote 7 |
| Kr | NA | NA | Ir | 3.0E+01 | Footnote 8 |
| Rb | 2.0E+03 | 6 | Pt | 1.0E+02 | Footnote 9 |
| Sr | 3.0E+01 | 6 | Au | 2.6E+01 | Footnote 10 |
| Y | 2.5E+01 | 6 | Hg | 2.0E+03 | Footnote 11 |
| Zr | 3.3E+00 | 6 | Tl | 2.2E+03 | Footnote 13 |
| Nb | 3.0E+04 | 6 | Pb | 3.0E+02 | 98 |
| Mo | 1.0E+01 | 6 | Bi | 2.0E+01 | 98 |
| Tc | 1.5E+01 | 6 | Ra | 5.0E+01 | 98 |
| Ru | 1.0E+01 | 6 | Th | 3.0E+01 | 98 |
| Rh | 1.0E+01 | 6 | U | 1.0E+01 | 98 |
| Pd | 1.0E+02 | Footnote 9 | Np | 1.0E+01 | 6 |
| Cd | 2.0E+03 | Footnote 11 | Am | 3.0E+01 | 98 |

Table 3-3 Footnotes:

NA = It is assumed that noble gases are not accumulated.

In Reference 6, see Table A-1.

A number of bioaccumulation factors could not be found in literature. In this case, the periodic table was used in conjunction with published element values. This method was used for periodic table columns except where there were no values for column 3A so the average of columns 2B and 4A was assigned.

1. Value is the average of Reference 6 values in literature for H, Na, Rb, and Cs.
2. Value is the average of Ref. 6 values in literature for Sr, Ba, and Ref. 98 values for Ra.
3. Value is the same as the Reference 6 value used for Y.
4. Value is the same as the Reference 6 value used for Zr.
5. Value is the same as the Reference 6 value used for Nb.
6. Value is the average of Reference 6 values in literature for Mn and Tc.
7. Value is the average of Reference 6 values in literature for Fe and Ru.
8. Value is the average of Reference 6 values in literature for Co and Rh.
9. Value is the same as the Reference 6 value used for Ni.
10. Value is the average of Reference 6 values in literature for Cu and Reference 56 value for Ag.
11. Value used is the same as the Reference 6 value used for Zn.
12. Value is the average of Reference 6 value in literature for C and Reference 98 value for Pb.
13. Value is the average of columns 2B and 4A, where column 2B is the "Reference 6 value for Zn" and column 4A is the average of "Reference 6 value for C and Reference 98 value for Pb."
14. Value is the average of Ref. 6 value found in literature for P and the Ref. 98 values for Bi and Sb.
15. Value is the same as the Reference 6 value used for Te.
16. Value is the average of Reference 6 values found in literature for Br and I.

4.0 Gaseous Effluents

4.1 Gaseous Effluents – General Information

- 4.1.1 This section reviews the offsite radiological limits applicable to the Dresden Station and presents in detail the equations and procedures used to assess compliance with these limits. This calculational approach incorporates certain simplifications such as:
- Pre-calculated atmospheric transport parameters are based on historical average atmospheric conditions. These historical meteorological conditions have resulted in the parameters shown in Table 4-2 through Table 4-10.
 - Use of pre-calculated dose factors based on historical average atmospheric conditions. For example, a dose factor with units (mrad/yr) per ($\mu\text{Ci}/\text{sec}$) is used to obtain dose rate in mrad/yr from noble gas release rate in $\mu\text{Ci}/\text{sec}$.
- 4.1.2 The equations and parameters of this section are for use in calculating offsite radiation doses during routine operating conditions. They are not for use in calculating doses due to non-routine releases (e.g., accident releases).
- 4.1.3 An overview of the required compliance is given in Table 1-1. The dose components are itemized and referenced, and an indication of their regulatory application is noted. Additionally, the locations of dose receivers for each dose component are given in Table 1-2.
- 4.1.4 Airborne Release Point Classifications - The pattern of dispersion of airborne releases is dependent on the height of the release point relative to adjacent structures. Each release point is classified as one of the following three height-dependent types:
- Stack (or Elevated) Release Point (denoted by the letter S or subscript s): These are release points approximately twice the height of adjacent solid structures. Releases are treated as elevated releases unaffected by the presence of the adjacent structures.
 - Ground Level Release Point (denoted by the letter G or subscript g): These are release points at ground level or lower than adjacent solid structures. Releases are considered drawn into the downwind wake of these structures and are treated as ground level releases.
 - Vent (or Mixed Mode) Release Point (denoted by the letter V or subscript v): These are release points as high or higher than adjacent solid structures but lower than twice the structures' heights. These releases are treated as a mixture of elevated and ground level releases. The proportion of the release attributed to either elevated or ground level in a vent release is determined by the ratio of stack exit velocity to wind speed.
- 4.1.5 10CFR50 Appendix I and the RECs contain requirements for the use of gaseous radwaste treatment and ventilation exhaust treatment.

- 4.1.6 The station must project doses due to gaseous releases from the site at least once per 31 days. The calculational methods shown in sections 4.2.2.1 and 4.2.2.2 are used for this dose projection.
- 4.1.7 For a release attributable to a processing or effluent system shared by more than one reactor unit, the dose due to an individual unit is obtained by proportioning the effluents among the units sharing the system. Allocation of gaseous effluents is described in Section 2.2.5.
- 4.1.8 The categories of radionuclides considered for each of the airborne effluent exposure pathways are summarized in Table 4-18.

4.2 Dose and Dose Rate Calculation Requirements

4.2.1 Instantaneous Dose Rates

4.2.1.1 To comply with required specifications, the effluent radiation monitors have a setpoint corresponding to an offsite total body dose rate below the limit (see Section 2.2.3). In addition, compliance is assessed by calculating offsite total body dose rate based on periodic samples obtained per station procedures.

4.2.1.2 Noble Gas: Total Body Dose Rate

RECs limit total body dose rate due to noble gases in gaseous effluents released from a site to areas at and beyond the site boundary to less than or equal to 500 mrem/yr at all times. The total body dose rate due to noble gases released in gaseous effluents is calculated by the following expression:

$$\dot{D}_{tb} = (1.11) \sum_i (\bar{S}_i \dot{Q}_{is} + \bar{V}_i \dot{Q}_{iv} + \bar{G}_i \dot{Q}_{ig}) \quad (4-1)$$

| | | |
|--|---|-----------------------------|
| where: | | (units) |
| \dot{D}_{tb} | Total Body Dose Rate - Dose rate to the total body due to gamma radiation from noble gas radionuclides released in gaseous effluents. | [mrem/yr] |
| 1.11 | Conversion factor to rem in tissue from rads in air. | [mrem/mrad] |
| $\dot{Q}_{is}, \dot{Q}_{iv}, \dot{Q}_{ig}$ | Release Rate - Measured release rate of radionuclide i from a stack, vent, or ground level release point, respectively. | [μ Ci/sec] |
| $\bar{S}_i, \bar{V}_i, \bar{G}_i$ | Gamma Total Body Dose Factor - Gamma total body dose rate at a specified location per unit of radioactivity release rate for radionuclide i released from a stack, vent, or ground level release point, respectively. The attenuation of gamma radiation due to passage through 1 cm of body tissue of 1 g/cm ³ density is taken into account in calculating this quantity. See Table 4-6. | [(mrad/yr)/(μ Ci/sec)] |

4.2.1.3 Noble Gas: Skin Dose Rate

RECs limit skin dose rate due to noble gases in gaseous effluents released from a site to areas at and beyond the site boundary to less than or equal to a dose rate of 3000 mrem/yr at all times. The skin dose rate due to noble gases released in gaseous effluents is calculated by the following expression:

$$\dot{D}_s = \sum_i \left(L_i \left(\left(\frac{\chi}{Q} \right)_s \dot{Q}'_{is} + \left(\frac{\chi}{Q} \right)_v \dot{Q}'_{iv} + \left(\frac{\chi}{Q} \right)_g \dot{Q}'_{ig} \right) + 1.11 (S_i \dot{Q}_{is} + V_i \dot{Q}_{iv} + G_i \dot{Q}_{ig}) \right) \quad (4-2)$$

where:

| | |
|---|---|
| | (units) |
| \dot{D}_s | Skin Dose Rate - Dose rate to skin due to beta and gamma radiation from noble gas radionuclides released in gaseous effluents. [mrem/yr] |
| L_i | Beta Skin Dose Factor - Beta skin dose rate per unit of radioactivity concentration for radionuclide i. Attenuation of beta radiation passing through 7 mg/cm ² of dead skin is accounted for. See Table 4-12. [(mrem/yr)/(μCi/m ³)] |
| $\left(\frac{\chi}{Q} \right)_{s,v,g}$ | Relative Concentration Factor – Radioactivity concentration at a specified location per unit of radioactivity release rate for a stack, vent, or ground level release, respectively. See Table 4-3. [(μCi/m ³)/(μCi/sec) _i , simplified to [sec/m ³] |
| $\dot{Q}'_{is}, \dot{Q}'_{iv}, \dot{Q}'_{ig}$ | Release Rate, Adjusted for Decay – Measured release rate of radionuclide i from a stack, vent, or ground release point, reduced to account for decay in transit from the release point to the dose point, and: [μCi/sec] |
| | $\dot{Q}'_{is} = \dot{Q}_{is} e^{-\frac{\lambda_i R}{3600u_s}}$, $\dot{Q}'_{iv} = \dot{Q}_{iv} e^{-\frac{\lambda_i R}{3600u_v}}$, $\dot{Q}'_{ig} = \dot{Q}_{ig} e^{-\frac{\lambda_i R}{3600u_g}}$ (4-3), (4-4), (4-5) |
| | where: |
| λ_i | Radiological Decay Constant for radionuclide i. See Table 1-6. [hr ⁻¹] |
| R | Radius - Downwind distance from the release point to the dose point. See Table 4-6. [m] |
| 3600 | Conversion factor to m/hr from m/sec. [sec/hr] |
| $u_{s,v,g}$ | Wind speed - Average wind speed for a stack, vent, or ground level release, respectively. See Table 4-2. [m/sec] |
| 1.11 | Conversion factor to rem in tissue from rads in air. [mrem/mrad] |
| $\dot{Q}_{is}, \dot{Q}_{iv}, \dot{Q}_{ig}$ | Release Rate - Measured release rate of radionuclide i from a stack, vent, or ground level release point, respectively. [μCi/sec] |
| S_i, V_i, G_i | Gamma Air Dose Factor - Gamma air dose rate at a specified location per unit of radioactivity release rate for radionuclide i released from a stack, vent, or ground level release point, respectively. See Table 4-6. [(mrad/yr)/(μCi/sec)] |

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4.2.1.4 Non-Noble Gas Radionuclides: Organ Dose Rate

RECs limit the dose rate to any organ, due to radioactive materials in gaseous effluents released from a site to areas at and beyond the site boundary, to less than or equal to a dose rate of 1500 mrem/yr. Dresden considers the adult to be the limiting receptor in calculating dose rate to organs due to inhalation of non-noble gas radionuclides in gaseous effluents. The dose rate to any organ in any age group due to inhalation is calculated by the following expression:

$$\dot{D}_{ja}^A = (1E6)(R_a) \sum_i \left(DFA_{ija} \left(\left(\frac{\chi}{Q} \right)_s \dot{Q}'_{is} + \left(\frac{\chi}{Q} \right)_v \dot{Q}'_{iv} + \left(\frac{\chi}{Q} \right)_g \dot{Q}'_{ig} \right) \right) \quad (4-6)$$

where:

| | | (units) | | | | | | | | | |
|---|--|---|--------------------|------------------|----------------|---------------------------------------|------------|-----------------------|--|------------------------------------|--|
| \dot{D}_{ja}^A | Inhalation Dose Rate - Rate of dose commitment to organ j of an individual in age group a due to inhalation of non-noble gas radionuclides released in gaseous effluents; j and a are chosen to correspond to an adult thyroid. | [mrem/yr] | | | | | | | | | |
| 1E6 | Conversion factor to pCi from μ Ci. | [pCi/ μ Ci] | | | | | | | | | |
| R_a | Individual Air Inhalation Rate - Air intake rate for individuals in age group a. See Table 1-5. | [m ³ /yr] | | | | | | | | | |
| DFA_{ija} | Inhalation Dose Commitment Factor - Dose Commitment to organ j of an individual in age group a per unit of radionuclide i inhaled. | [mrem/pCi] | | | | | | | | | |
| | <table border="0" style="width: 100%;"> <thead> <tr> <th style="text-align: left;"><u>Assessment</u></th> <th style="text-align: left;"><u>Dose Factor</u></th> <th style="text-align: left;"><u>Age Group</u></th> </tr> </thead> <tbody> <tr> <td>10CFR50 App. I</td> <td>Reg. Guide 1.109 Tables E-7 – E-10</td> <td>All (four)</td> </tr> <tr> <td>10CFR20 / 40CFR190</td> <td>Federal Guidance Report No. 11, Table 2.1</td> <td>Adult only (average individual)</td> </tr> </tbody> </table> | <u>Assessment</u> | <u>Dose Factor</u> | <u>Age Group</u> | 10CFR50 App. I | Reg. Guide 1.109 Tables E-7 – E-10 | All (four) | 10CFR20 / 40CFR190 | Federal Guidance Report No. 11, Table 2.1 | Adult only (average individual) | |
| <u>Assessment</u> | <u>Dose Factor</u> | <u>Age Group</u> | | | | | | | | | |
| 10CFR50 App. I | Reg. Guide 1.109 Tables E-7 – E-10 | All (four) | | | | | | | | | |
| 10CFR20 / 40CFR190 | Federal Guidance Report No. 11, Table 2.1 | Adult only (average individual) | | | | | | | | | |
| $\left(\frac{\chi}{Q} \right)_{s,v,g}$ | Relative Concentration Factor – Radioactivity concentration at a specified location per unit of radioactivity release rate for a stack, vent, or ground level release, respectively. See Table 4-3. | [[μ Ci/m ³]/(μ Ci/sec)] _i simplified to [sec/m ³] | | | | | | | | | |
| $\dot{Q}'_{is}, \dot{Q}'_{iv}, \dot{Q}'_{ig}$ | Release Rate, Adjusted for Decay – Measured release rate of radionuclide i from a stack, vent, or ground release point, reduced to account for decay in transit from the release point to the dose point. See Equations 4-3, 4-4, and 4-5. | [μ Ci/sec] | | | | | | | | | |

RECs require the dose rate due to non-noble gas radioactive materials in airborne effluents be determined to be within the above limit in accordance with a sampling and analysis program specified in the RECs. To comply with this specification, the station obtains and analyzes samples in accordance with the sampling and analysis program in the RECs. The adult organ dose rate due to inhalation is calculated in each sector at the location of the highest offsite χ/Q (see Table 4-3). The result for the sector with the highest organ inhalation dose rate is compared to the limit.

4.2.2 Dose from Noble Gas Radionuclides

4.2.2.1 Gamma Air Dose

RECs limit the gamma air dose due to noble gas effluents released from each reactor unit to areas at and beyond the site boundary to the following:

- Less than or equal to 5 mrad per calendar quarter.
- Less than or equal to 10 mrad per calendar year.

The gamma air dose due to noble gases released in gaseous effluents is calculated by the following expression:

$$D_{\gamma} = (3.17E - 08) \sum_i (S_i Q_{is} + V_i Q_{iv} + G_i Q_{ig}) \quad (4-7)$$

| | | |
|--------------------------|--|-----------------------|
| where: | | (units) |
| D_{γ} | Gamma Air Dose - Dose to air due to gamma radiation from noble gas radionuclides released in gaseous effluents. | [mrad] |
| 3.17E-08 | Conversion factor to years from seconds. | [yr/sec] |
| S_i, V_i, G_i | Gamma Air Dose Factor - Gamma air dose rate at a specified location per unit of radioactivity release rate for radionuclide i released from a stack, vent, or ground level release point, respectively. See Table 4-6. | [(mrad/yr)/(μCi/sec)] |
| Q_{is}, Q_{iv}, Q_{ig} | Cumulative Radionuclide Release - Measured cumulative release of radionuclide i over the time period of interest from a stack, vent, or ground release point, respectively. | [μCi] |

RECs require determination of cumulative and projected gamma air dose contributions due to noble gases at least once per 31 days. The dose factors in Table 4-6 are used for the determinations required. These values were calculated for the site boundary in each sector and are judged to be very good approximations to the maximum offsite values. After doses for all sectors are determined, the highest dose is compared with the RECs limit on gamma air dose.

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4.2.2.2 Beta Air Dose

RECs limit beta air dose due to noble gases in gaseous effluents released from each reactor unit to areas at and beyond the site boundary to the following:

- Less than or equal to 10 mrad per calendar quarter.
- Less than or equal to 20 mrad per calendar year.

The beta air dose due to noble gases released in gaseous effluents is calculated by the following expression:

$$D_{\beta} = (3.17E - 08) \sum_i \left(N_i \left(\left(\frac{\chi}{Q} \right)_s Q'_{is} + \left(\frac{\chi}{Q} \right)_v Q'_{iv} + \left(\frac{\chi}{Q} \right)_g Q'_{ig} \right) \right) \quad (4-8)$$

where:

| | | |
|---|--|---|
| | | (units) |
| D_{β} | Beta Air Dose - Dose to air due to beta radiation from noble gas radionuclides released in gaseous effluents. | [mrad] |
| 3.17E-08 | Conversion factor to years from seconds. | [yr/sec] |
| N_i | Beta Air Dose Factor - Beta air dose rate per unit of radioactivity concentration for radionuclide i. See Table 4-12 | [(mrad/yr)/(μCi/m ³)] |
| $\left(\frac{\chi}{Q} \right)_{s,v,g}$ | Relative Concentration Factor – Radioactivity concentration at a specified location per unit of radioactivity release rate for a stack, vent, or ground level release, respectively. See Table 4-3. | [(μCi/m ³)/(μCi/sec) _i , simplified to [sec/m ³] |
| $Q'_{is}, Q'_{iv}, Q'_{ig}$ | Cumulative Radionuclide Release, Adjusted for Decay - Measured cumulative release of radionuclide i over the time period of interest from a stack, vent, or ground release point, respectively, reduced to account for decay in transit from release point to dose point, and: | [μCi] |

$$Q'_{is} = Q_{is} e^{-\frac{\lambda_i R}{3600 u_s}}, \quad Q'_{iv} = Q_{iv} e^{-\frac{\lambda_i R}{3600 u_v}}, \quad Q'_{ig} = Q_{ig} e^{-\frac{\lambda_i R}{3600 u_g}} \quad (4-9), (4-10), (4-11)$$

where:

| | | |
|--------------------------|---|---------------------|
| λ_i | Radiological Decay Constant for radionuclide i. See Table 1-6. | [hr ⁻¹] |
| R | Radius - Downwind distance from the release point to the dose point. See Table 4-6. | [m] |
| 3600 | Conversion factor to m/hr from m/sec. | [sec/hr] |
| $u_{s,v,g}$ | Wind speed - Average wind speed for a stack, vent, or ground level release, respectively. See Table 4-2. | [m/sec] |
| Q_{is}, Q_{iv}, Q_{ig} | Cumulative Radionuclide Release - Measured cumulative release of radionuclide i over the time period of interest from a stack, vent, or ground release point, respectively. | [μCi] |

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RECs require determination of cumulative and projected beta air dose contributions due to noble gases at least once per 31 days.

Beta air dose is determined for each sector using the highest calculated offsite value of χ/Q for that sector. This value and the applicable distance R are provided in Table 4-3. The highest dose is compared with the RECs limit on beta air dose.

4.2.2.3 Total Body Dose (Deep Dose Equivalent)

The total body dose to any receiver is due, in part, to gamma radiation emitted from radioactivity in airborne effluents. This component is added to others to demonstrate compliance to the requirements of 40CFR190 and 10CFR20.

The total body dose component due to gamma radiation from noble gases released in gaseous effluents is calculated by the following expression:

$$D_{tb} = (0.7)(1.11)(3.17E-08) \sum_i (\bar{S}_i Q_{is} + \bar{V}_i Q_{iv} + \bar{G}_i Q_{ig}) \quad (4-12)$$

| | | |
|-----------------------------------|--|---------------------------------|
| where: | | (units) |
| D_{tb} | Total Body Dose - Dose to the total body due to gamma radiation from noble gas radionuclides released in gaseous effluents. | [mrem] |
| 0.7 | Shielding Factor to account for shielding due to the occupancy of structures, dimensionless. | |
| 1.11 | Conversion factor to rem in tissue from rads in air. | [mrem/mrad] |
| 3.17E-08 | Conversion factor to years from seconds. | [yr/sec] |
| $\bar{S}_i, \bar{V}_i, \bar{G}_i$ | Gamma Total Body Dose Factor - Gamma total body dose rate at a specified location per unit of radioactivity release rate for radionuclide i released from a stack, vent, or ground level release point, respectively. The attenuation of gamma radiation due to passage through 1 cm of body tissue of 1 g/cm ³ density is taken into account in calculating this quantity. See Tables 4-6 and 4-7. | [(mrad/yr)/ (μ Ci/sec)] |
| Q_{is}, Q_{iv}, Q_{ig} | Cumulative Radionuclide Release - Measured cumulative release of radionuclide i over the time period of interest from a stack, vent, or ground release point, respectively. | [μ Ci] |

The total body dose is also calculated for the 40CFR190 and 10CFR20 compliance assessments. In some cases, the total body dose may be required in 10CFR50 Appendix I assessments (See Part II Table 1-1).

4.2.2.4 Skin Dose (Shallow Dose Equivalent)

There is no regulatory requirement to evaluate skin dose. However, this component is evaluated for reference as there is skin dose design objective contained in 10CFR50 Appendix I. Note that in the unlikely event that if beta air dose guideline is exceeded, then the skin dose will require evaluation. The part of skin dose due to noble gases released in gaseous effluents is calculated by the following expression:

$$D_s = (3.17E-08) \sum_i \left(L_i \left(\left(\frac{\chi}{Q} \right)_s Q'_{is} + \left(\frac{\chi}{Q} \right)_v Q'_{iv} + \left(\frac{\chi}{Q} \right)_g Q'_{ig} \right) + (0.7)(1.11)(S_i Q_{is} + V_i Q_{iv} + G_i Q_{ig}) \right) \quad (4-13)$$

| | | |
|---|--|---|
| where: | | (units) |
| D_s | Skin Dose - Dose to the skin due to beta and gamma radiation from noble gas radionuclides released in gaseous effluents. | [mrem] |
| 3.17E-08 | Conversion factor to years from seconds. | [yr/sec] |
| L_i | Beta Skin Dose Factor - Beta skin dose rate per unit of radioactivity concentration for radionuclide i. Attenuation of beta radiation passing through 7 mg/cm ² of dead skin is accounted for. See Table 4-12. | [(mrem/yr)/(μCi/m ³)] |
| $\left(\frac{\chi}{Q} \right)_{s,v,g}$ | Relative Concentration Factor – Radioactivity concentration at a specified location per unit of radioactivity release rate for a stack, vent, or ground level release, respectively. See Tables 4-3 and 4-4. | [(μCi/m ³)/(μCi/sec)], simplified to [sec/m ³] |
| $Q'_{is}, Q'_{iv}, Q'_{ig}$ | Cumulative Radionuclide Release, Adjusted for Decay - Measured cumulative release of radionuclide i over the time period of interest from a stack, vent, or ground release point, respectively, reduced to account for decay in transit from release point to dose point. See Equations 4-9, 4-10, and 4-11. | [μCi] |
| 0.7 | Shielding Factor to account for shielding due to the occupancy of structures, dimensionless. | |
| 1.11 | Conversion factor to rem in tissue from rads in air. | [mrem/mrad] |
| S_i, V_i, G_i | Gamma Air Dose Factor - Gamma air dose rate at a specified location per unit of radioactivity release rate for radionuclide i released from a stack, vent, or ground level release point, respectively. See Tables 4-6 and 4-7. | [(mrad/yr)/(μCi/sec)] |
| Q_{is}, Q_{iv}, Q_{ig} | Cumulative Radionuclide Release - Measured cumulative release of radionuclide i over the time period of interest from a stack, vent, or ground release point, respectively. | [μCi] |

The skin dose is calculated for reference only.

4.2.3 Dose from Non-Noble Gas Radionuclides

RECs provide the following limits, based on 10CFR50 Appendix I, on the dose to a member of the public from specified non-noble gas radionuclides in gaseous effluents released from each unit to areas at and beyond the site boundary:

- Less than or equal to 7.5 mrem to any organ during any calendar quarter
- Less than or equal to 15 mrem to any organ during any calendar year

The individual dose components are also required as part of the 40CFR190 assessments and combined as part of the 10CFR20 assessment (See Table 1-1). The deep dose due to radionuclides deposited on the ground is considered to be a component of the deep dose equivalent for 10CFR20 compliance and an organ (total body) dose component for 10CFR50 Appendix I and 40CFR190 compliance.

Note that as a result of historical regulation evolution, committed dose equivalent assessments for 10CFR20 and 40CFR190 compliance are made for an adult using Federal Guidance Report No. 11 (Reference 93) dose conversion factors; assessments for 10CFR50 Appendix I compliance are made for the four age groups using Regulatory Guide 1.109 (Reference 6) dose conversion factors.

The committed dose equivalent is calculated for releases in the time period under consideration. Specifically, the CDE is calculated as the sum of two contributors:

$$D_{ja}^{NNG} = D_{ja}^A + D_{ja}^D \quad (4-14)$$

| | | |
|----------------|--|---------|
| where: | | (units) |
| D_{ja}^{NNG} | Committed Dose Equivalent due to Non-Noble Gas Radionuclides - Sum of the dose to organ j of an individual of age group a due to non-noble gas radionuclides released in gaseous effluents during a specified time period. | [mrem] |
| D_{ja}^A | Inhalation Committed Dose Equivalent - Dose to organ j of an individual of age group a due to inhalation of non-noble gas radionuclides released in gaseous effluents. See Equation 4-18. | [mrem] |
| D_{ja}^D | Food Pathways Committed Dose Equivalent - Dose due to ingestion via food pathways (leafy vegetables, produce, milk, and meat) of non-noble gas radionuclides released in gaseous effluents. See Equation 4-19. | [mrem] |

RECs require cumulative and projected dose contributions for the specified non-noble gas radionuclides in airborne effluents to be determined at least once per 31 days.

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To comply with this specification, Dresden obtains and analyzes samples in accordance with the radioactive gaseous waste or gaseous effluent sampling and analysis program in the RECs. For each organ of each age group considered, the dose for each pathway is calculated in every sector. The calculation is based on the location assumptions discussed below in conjunction with the pathway equations. For each organ of each age group, the doses are summed in each sector over all pathways. The result for the sector with the highest total dose is compared to the limit.

4.2.3.1 Ground Deposition (Deep Dose Equivalent)

The dose due to ground deposition of radioactivity is considered to be a total body dose (deep dose equivalent) component and is calculated by the following expressions:

$$D^G = (24)(0.7)t_r \sum_i (DFG_{ij} C_i^G) \quad (4-15)$$

| | | |
|--------------------------------------|--|--|
| where: | | (units) |
| D^G | Ground Deposition Deep Dose Equivalent - Dose due to radiation from non-noble gas radionuclides released in gaseous effluents. | [mrem] |
| 24 | Conversion factor to hours from days. | [hr/day] |
| 0.7 | Shielding Factor to account for shielding due to the occupancy of structures, dimensionless. | |
| t_r | Release or Exposure Period - Time period of the calculation (e.g., number of days in the quarter for a calendar quarter calculation). | [hr] |
| DFG_{ij} | Ground Plane Dose Conversion Factor - Dose rate to the total body per unit of ground radioactivity concentration due to standing on ground uniformly contaminated with radionuclide i. See Table 4-13. | [(mrem/hr)/(pCi/m ²)] |
| C_i^G | Ground Plane Concentration - Concentration of radionuclide i on the ground, where: | [pCi/m ²] |
| | $C_i^G = \left(\frac{d_i}{\lambda_i} \right) (1 - e^{-\lambda_i t_b})$ | (4-16) |
| λ_i | Radiological Decay Constant for radionuclide i. See Table 1-6. | [hr ⁻¹] |
| t_b | Ground Deposition Period - Time period during which the radioactivity is assumed to have been deposited. See Table 4-14. | [hr] |
| d_i | Deposition Rate - Rate at which radionuclide i is deposited on the ground, where: | [(pCi/hr)/m ²] |
| | $d_i = \left(\frac{1E6}{24t_r} \right) \left(Q'_{is} \left(\frac{D}{Q} \right)_s + Q'_{iv} \left(\frac{D}{Q} \right)_v + Q'_{ig} \left(\frac{D}{Q} \right)_g \right)$ | (4-17) |
| 1E6 | Conversion factor to pCi from μ Ci. | [pCi/ μ Ci] |
| 24 | Conversion factor to hours from days. | [hr/day] |
| $Q'_{is}, Q'_{iv}, Q'_{ig}$ | Cumulative Radionuclide Release, Adjusted for Decay - Measured cumulative release of radionuclide i over the time period of interest from a stack, vent, or ground release point, respectively, reduced to account for decay in transit from release point to dose point. See Equations 4-9, 4-10, and 4-11. | [μ Ci] |
| $\left(\frac{D}{Q} \right)_{s,v,g}$ | Relative Deposition Factor - Rate of deposition of radioactivity at a specified location per unit of radioactivity release rate for a stack, vent, or ground level release, respectively. See Tables 4-3, 4-4, and 4-5. | [pCi/(m ² sec) per pCi/sec], simplified to [m ⁻²] |

The deep dose equivalent due to ground deposition is determined for each sector using the highest calculated offsite value of D/Q for that sector. This value and the applicable distance R are provided in Tables 4-3 and 4-4. This dose component is included in the calculation of the total deep dose equivalent (Equation 5-2).

4.2.3.2 Inhalation (Committed Dose Equivalent)

The committed dose equivalent due to inhalation is calculated by the following expression:

$$D_{ja}^A = (3.17E-08)(1E6)(R_a) \sum_i \left(DFA_{ija} \left(\left(\frac{\chi}{Q} \right)_s Q'_{is} + \left(\frac{\chi}{Q} \right)_v Q'_{iv} + \left(\frac{\chi}{Q} \right)_g Q'_{ig} \right) \right) \quad (4-18)$$

where:

| | | (units) | | | | | | | | | |
|---|---|---|-------------|-----------|---------------|---------------------------------------|------------|-----------------------|--|------------------------------------|--|
| D_{ja}^A | Inhalation Committed Dose Equivalent - Dose to organ j of an individual in age group a due to inhalation of non-noble gas radionuclides released in gaseous effluents. | [mrem] | | | | | | | | | |
| 3.17E-08 | Conversion factor to years from seconds. | [yr/sec] | | | | | | | | | |
| 1E6 | Conversion factor to pCi from μ Ci. | [pCi/ μ Ci] | | | | | | | | | |
| R_a | Individual Air Inhalation Rate - Air intake rate for individuals in age group a. See Table 1-5. | [m ³ /yr] | | | | | | | | | |
| DFA_{ija} | Inhalation Dose Commitment Factor - Dose Commitment to organ j of an individual in age group a per unit of radionuclide i inhaled. | [mrem/pCi] | | | | | | | | | |
| | <table border="0" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: left; border-bottom: 1px solid black;">Assessment</th> <th style="text-align: left; border-bottom: 1px solid black;">Dose Factor</th> <th style="text-align: left; border-bottom: 1px solid black;">Age Group</th> </tr> </thead> <tbody> <tr> <td>10CFR50 App I</td> <td>Reg. Guide 1.109 Tables E-7 – E-10</td> <td>All (four)</td> </tr> <tr> <td>10CFR20 / 40CFR190</td> <td>Federal Guidance Report No. 11, Table 2.1</td> <td>Adult only (average individual)</td> </tr> </tbody> </table> | Assessment | Dose Factor | Age Group | 10CFR50 App I | Reg. Guide 1.109 Tables E-7 – E-10 | All (four) | 10CFR20 / 40CFR190 | Federal Guidance Report No. 11, Table 2.1 | Adult only (average individual) | |
| Assessment | Dose Factor | Age Group | | | | | | | | | |
| 10CFR50 App I | Reg. Guide 1.109 Tables E-7 – E-10 | All (four) | | | | | | | | | |
| 10CFR20 / 40CFR190 | Federal Guidance Report No. 11, Table 2.1 | Adult only (average individual) | | | | | | | | | |
| $\left(\frac{\chi}{Q} \right)_{s,v,g}$ | Relative Concentration Factor – Radioactivity concentration at a specified location per unit of radioactivity release rate for a stack, vent, or ground level release, respectively. See Tables 4-3 and 4-4. | [μ Ci/m ³ per μ Ci/sec], simplified to [sec/m ³] | | | | | | | | | |
| $Q'_{is}, Q'_{iv}, Q'_{ig}$ | Cumulative Radionuclide Release, Adjusted for Decay - Measured cumulative release of radionuclide i over the time period of interest from a stack, vent, or ground release point, respectively, reduced to account for decay in transit from release point to dose point. See Equations 4-9, 4-10, and 4-11. | [μ Ci] | | | | | | | | | |

The committed dose equivalent due to inhalation is determined for each sector using the highest calculated offsite value of χ/Q for that sector. This value and the applicable distance R are provided in Tables 4-3 and 4-4. This dose component is included within the total committed dose equivalent from all pathways (see Equations 4-14 and 5-5).

4.2.3.3 Food Pathways

The committed dose equivalent due to food pathways is calculated by the following expression:

$$D_{ja}^D = \left(\frac{t_r}{365} \right) \sum_i \left(DFI_{ija} \left(U_a^v f_g C_i^v + U_a^m C_i^m + U_a^F C_i^F + U_a^L f_\ell C_i^L \right) \right) \quad (4-19)$$

| where: | | (units) | | | | | | | | | |
|------------------------------|--|---------------------------------|--------------------|------------------|---------------|--|------------|--------------------|--|---------------------------------|--|
| D_{ja}^D | Ground Deposition Deep Dose Equivalent - Dose due to radiation from non-noble gas radionuclides released in gaseous effluents. | [mrem] | | | | | | | | | |
| t_r | Release or Exposure Period - Time period of the calculation (e.g., number of days in the quarter for a calendar quarter calculation). | [hr] | | | | | | | | | |
| 365 | Conversion factor to days from years. | [days/yr] | | | | | | | | | |
| DFI_{ija} | Ingestion Dose Commitment Factor - Dose Commitment to organ j of an individual in age group a per unit of radionuclide i ingested. | [mrem/pCi] | | | | | | | | | |
| | <table border="0" style="margin-left: 40px;"> <thead> <tr> <th style="text-align: left;"><u>Assessment</u></th> <th style="text-align: left;"><u>Dose Factor</u></th> <th style="text-align: left;"><u>Age Group</u></th> </tr> </thead> <tbody> <tr> <td>10CFR50 App.I</td> <td>Reg. Guide 1.109 Tables E-11 – E-14</td> <td>All (four)</td> </tr> <tr> <td>10CFR20 / 40CFR190</td> <td>Federal Guidance Report No. 11, Table 2.2</td> <td>Adult only (average individual)</td> </tr> </tbody> </table> | <u>Assessment</u> | <u>Dose Factor</u> | <u>Age Group</u> | 10CFR50 App.I | Reg. Guide 1.109 Tables E-11 – E-14 | All (four) | 10CFR20 / 40CFR190 | Federal Guidance Report No. 11, Table 2.2 | Adult only (average individual) | |
| <u>Assessment</u> | <u>Dose Factor</u> | <u>Age Group</u> | | | | | | | | | |
| 10CFR50 App.I | Reg. Guide 1.109 Tables E-11 – E-14 | All (four) | | | | | | | | | |
| 10CFR20 / 40CFR190 | Federal Guidance Report No. 11, Table 2.2 | Adult only (average individual) | | | | | | | | | |
| U_a^v | Produce Consumption Rate - Annual consumption (usage) rate of produce for individuals in age group a. See Table 1-5. | [kg/yr] | | | | | | | | | |
| U_a^m | Milk Consumption Rate - Annual consumption (usage) rate of milk for individuals in age group a. See Table 1-5. | [L/yr] | | | | | | | | | |
| U_a^F | Meat Consumption Rate - Annual consumption (usage) rate of meat for individuals in age group a. See Table 1-5. | [kg/yr] | | | | | | | | | |
| U_a^L | Leafy Vegetable Consumption Rate - Annual consumption (usage) rate of leafy vegetables for individuals in age group a. See Table 1-5. | [kg/yr] | | | | | | | | | |
| f_g | Affected Fraction, Produce - The fraction of ingested produce that is produced in the garden of interest. See Table 4-14, dimensionless. | | | | | | | | | | |
| f_ℓ | Affected Fraction, Leafy Vegetables - The fraction of ingested leafy vegetables that are produced in the garden of interest. See Table 4-14, dimensionless. | | | | | | | | | | |
| $C_i^v, C_i^m, C_i^F, C_i^L$ | Radioactivity Concentration - The average concentration of radionuclide i in produce, milk, meat, and leafy vegetables, respectively. Calculated in the following sections 4.2.3.3.1 through 4.2.3.3.4, respectively. | [pCi/kg] | | | | | | | | | |

4.2.3.3.1 Radioactivity Concentration in Produce

The radioactivity concentration in produce is calculated by the following expression:

$$C_i^v = \left(\frac{d_i r}{Y_v \lambda_{EI}} \right) (1 - e^{-\lambda_{EI} t_e}) (e^{-\lambda_i t_h}) f_f \quad (4-20)$$

| | | |
|----------------|---|----------------------------|
| where: | | (units) |
| C_i^v | Produce Radioactivity Concentration - The average concentration of radionuclide i in produce grown in the garden of interest. Calculated from the amount of radioactivity released and the D/Q at the garden of interest. | [pCi/kg] |
| d_i | Deposition Rate - Rate at which radionuclide i is deposited on the ground. See Equation 4-17. | [(pCi/hr)/m ²] |
| r | Vegetation Retention Factor - Fraction of deposited activity retained on vegetation. See Table 4-14, dimensionless. | |
| Y_v | Agricultural Productivity Yield - The quantity of vegetation produced per unit area of the land on which the vegetation is grown. See Table 4-14. | [kg/m ²] |
| λ_{EI} | Effective Decay Constant - The effective removal rate constant for radionuclide i from vegetation, where: | [hr ⁻¹] |
| | $\lambda_{EI} = \lambda_i + \lambda_w$ | (4-21) |
| λ_i | Radiological Decay Constant for radionuclide i. See Table 1-6. | [hr ⁻¹] |
| λ_w | Weathering Decay Constant - Removal constant for physical loss by weathering. See Table 4-14. | [hr ⁻¹] |
| t_e | Effective Vegetation Exposure Time - Time that vegetation is exposed to contamination during the growing season. See Table 4-14. | [hr] |
| t_h | Harvest to Consumption Time - Time between harvest and consumption. See Table 4-14. | [hr] |
| f_f | Seasonal Growing Factor - Factor that accounts for the seasonal growth of vegetation. It has the value of '1' during the growing season (May - October), '0' otherwise. See Table 4-14, dimensionless. | |

4.2.3.3.2 Radioactivity Concentration in Milk

The radioactivity concentration in milk is calculated by the following expression:

$$C_i^m = F_m (f_p f_s C_i^P + (1 - f_p) C_i^s + f_p (1 - f_s) C_i) Q_f e^{-\lambda_i t_f} \quad (4-22)$$

| | | |
|---------|---|---|
| where: | | (units) |
| C_i^m | Milk Radioactivity Concentration - The average concentration of radionuclide i in milk from the producer of interest. Calculated from the amount of radioactivity released and the D/Q at the location of the producer of interest. | [pCi/L] |
| F_m | Stable Element Transfer Coefficient for Milk - Fraction of an animal's daily intake of radionuclide i which appears in each liter of milk. See Table 4-15. | [(pCi/L)/(pCi/day)], simplified to [day/L] |
| f_p | Pasture Time Fraction - The fraction of the year that animals graze on pasture. See Table 4-14, dimensionless. | |
| f_s | Pasture Grass Fraction - The fraction of daily feed that is pasture grass when the animal grazes on pasture. See Table 4-14, dimensionless. | |
| C_i^P | Pasture Grass Radioactivity Concentration - The concentration of radionuclide i on pasture grass. Calculated as C_i using Equation 4-23 using parameter values specified for the pasture grass and milk pathways in Table 4-14. | [pCi/kg] |
| C_i^s | Stored Feed Radioactivity Concentration - The concentration of radionuclide i in stored feed. Calculated as C_i in Equation 4-23 using parameter values specified for the stored feed and milk pathways in Table 4-14. | [pCi/kg] |
| C_i | Feed Radioactivity Concentration - The concentration of radionuclide i in pasture grass or stored animal feed. | [pCi/kg] |
| | $C_i = \left(\frac{d_i r}{Y_v \lambda_{Ei}} \right) (1 - e^{-\lambda_{Ei} t_o}) (e^{-\lambda_i t_h}) \quad (4-23)$ | |
| | Terms are defined under Equation 4-20. The Seasonal Growing Factor f_r is not applicable. | |
| Q_f | Feed Consumption Rate - Amount of feed consumed by the animal per day. See Table 4-14. | [kg/day] |
| t_f | Milk Transport Time - The average transport time of the activity from the feed into the milk and to the receptor. See Table 4-14. | [days] |

4.2.3.3.3 Radioactivity Concentration in Meat

The radioactivity concentration in meat is calculated by the following expression:

$$C_i^F = F_f (f_p f_s C_i^P + (1 - f_p) C_i^S + f_p (1 - f_s) C_i^S) Q_f e^{-\lambda_i t_s} \quad (4-24)$$

where:

| | | |
|---------|---|---|
| | | (units) |
| C_i^F | Meat Radioactivity Concentration - The average concentration of radionuclide i in meat from the producer of interest. Calculated from the amount of radioactivity released and the D/Q at the location of the producer of interest. | [pCi/kg] |
| F_f | Stable Element Transfer Coefficient for Meat - Fraction of an animal's daily intake of radionuclide i which appears in each kilogram of flesh. See Table 4-15. | [(pCi/kg)/(pCi/day)], simplified to [day/kg] |
| f_p | Pasture Time Fraction - The fraction of the year that animals graze on pasture. See Table 4-14, dimensionless. | |
| f_s | Pasture Grass Fraction - The fraction of daily feed that is pasture grass when the animal grazes on pasture. See Table 4-14, dimensionless. | |
| C_i^P | Pasture Grass Radioactivity Concentration - The concentration of radionuclide i on pasture grass. Calculated as C_i using Equation 4-25 using parameter values specified for the pasture grass and meat pathways in Table 4-14. | [pCi/kg] |
| C_i^S | Stored Feed Radioactivity Concentration - The concentration of radionuclide i in stored feed. Calculated as C_i in Equation 4-25 using parameter values specified for the stored feed and meat pathways in Table 4-14. | [pCi/kg] |
| C_i | Feed Radioactivity Concentration - The concentration of radionuclide i in pasture grass or stored animal feed. | [pCi/kg] |
| | $C_i = \left(\frac{d_i r}{Y_v \lambda_{Ei}} \right) (1 - e^{-\lambda_{Ei} t_o}) (e^{-\lambda_i t_h}) \quad (4-25)$ | |
| | Terms are defined under Equation 4-20. (The Seasonal Growing Factor f_f is not applicable.) | |
| Q_f | Feed Consumption Rate - Amount of feed consumed by the animal per day. See Table 4-14. | [kg/day] |
| t_s | Time from Slaughter to Consumption - Average time from slaughter to consumption. See Table 4-14. | [days] |

4.2.3.3.4 Radioactivity Concentration in Leafy Vegetables

The radioactivity concentration in leafy vegetables is calculated by the following expression:

$$C_i^L = \left(\frac{d_i r}{Y_v \lambda_{Ei}} \right) (1 - e^{-\lambda_{Ei} t_e}) (e^{-\lambda_i t_h}) f_r \quad (4-26)$$

| | | |
|----------------|---|----------------------------|
| where: | | (units) |
| C_i^L | Leafy Vegetables Radioactivity Concentration - The average concentration of radionuclide i in leafy vegetables. Calculated from the amount of radioactivity released and the D/Q at the garden of interest. | [pCi/kg] |
| d_i | Deposition Rate - Rate at which radionuclide i is deposited on the ground. See Equation 4-17. | [(pCi/hr)/m ²] |
| r | Vegetation Retention Factor - Fraction of deposited activity retained on vegetation. See Table 4-14, dimensionless. | |
| Y_v | Agricultural Productivity Yield - The quantity of vegetation produced per unit area of the land on which the vegetation is grown. See Table 4-14. | [kg/m ²] |
| λ_{Ei} | Effective Decay Constant - The effective removal rate constant for radionuclide i from vegetation, where: | [hr ⁻¹] |
| | $\lambda_{Ei} = \lambda_i + \lambda_w \quad (4-27)$ | |
| λ_i | Radiological Decay Constant for radionuclide i. See Table 1-6. | [hr ⁻¹] |
| λ_w | Weathering Decay Constant - Removal constant for physical loss by weathering. See Table 4-14. | [hr ⁻¹] |
| t_e | Effective Vegetation Exposure Time - Time that vegetation is exposed to contamination during the growing season. See Table 4-14. | [hr] |
| t_h | Harvest to Consumption Time - Time delay between harvest of vegetation or crops and consumption. See Table 4-14. | [hr] |
| f_r | Seasonal Growing Factor - Factor that accounts for the seasonal growth of vegetation. It has the value of '1' during the growing season (May - October), '0' otherwise. See Table 4-14, dimensionless. | |

4.3 Meteorological Models and Parameters for Airborne Effluent Calculations

4.3.1 Introduction

The equations used for calculation of doses due to radioactive airborne effluents are given previously in this section. The equations involve the following types of parameters:

- **Meteorological Parameters**
These include χ/Q , D/Q and wind speed. Their values are based on historical average atmospheric conditions at Dresden for a selected multi-year historical period.
- **Dose Factors**
These parameters are used to provide a simple way to calculate doses and dose rates due to gamma and beta radiation. Some of these parameters are independent of meteorological conditions. Others have values based on historical average atmospheric conditions for a selected multi-year historical period.
- **Measured Release Parameters**
These are measured values of radioactivity releases and release rates.
- **Radiological Decay Constants**
These are used to account for the radioactive decay between the release of radioactivity to the environment and the exposure of persons to it.
- **Production/Exposure Parameters**
These are parameters characterizing agricultural production (e.g., length of growing season, transport times) and human exposure patterns (e.g., exposure period, breathing rate, food consumption rates). These parameters affect the quantities of radioactivity to which persons may be exposed.

This section discusses the methodology used to determine values of these parameters. Section 4.3.2 addresses how the historical meteorology of a site is characterized by use of a function called the joint frequency distribution. Section 4.3.2 and Sections 4.3.4 through 4.3.7 present equations that use the joint frequency distribution to obtain values for site-specific meteorological and dose parameters. Most of these equations involve a mathematical model of a plume known as the Gaussian plume model. This model is developed in Section 4.3.3. Various generic dose factors are discussed in Sections 4.3.8 through 4.3.11. The other parameters are discussed in the remaining sections.

4.3.2 Meteorological Data and Parameters

Predicting where airborne effluent will travel requires information on the following:

- Wind speed
- Wind direction
- Atmospheric turbulence

The greater the atmospheric turbulence, the more an effluent plume will tend to broaden and the more dilute the concentration will be. Atmospheric turbulence is affected by the general condition of the atmosphere (e.g., the vertical temperature distribution) and by local features (e.g., objects that protrude into the wind stream). A commonly used classification scheme for the degree of atmospheric turbulence associated with the general condition of the atmosphere involves seven stability classes:

- A Extremely Unstable
- B Moderately Unstable
- C Slightly Unstable
- D Neutral
- E Slightly Stable
- F Moderately Stable
- G Extremely Stable

This classification scheme is based on Reference 5, Table 1. Each class is associated with a particular range of wind direction fluctuations and of vertical temperature gradients in the atmosphere. These are specified in Table 4-16.

4.3.2.1 Data

Historical atmospheric conditions at Dresden were recorded by an instrumented meteorological tower that measured wind speed, wind direction, and temperature at various heights. Hourly average values of wind speed, wind direction, and stability class were determined. The difference in temperature between two heights was used to assign an atmospheric stability class based on the correlation between temperature gradient and stability class in Table 4-16.

In obtaining the data, quality assurance checks and corrections were made. Also, corrections were applied to compensate for the limitations of wind sensors at low speeds. A calm was said to exist if the wind speed was less than that of the threshold of either the anemometer (wind speed meter) or the wind direction vane. For calm conditions, a wind speed equal to one-half of the higher threshold was assigned. For each stability class, the wind directions during calm conditions were assumed to be distributed in proportion to the observed wind direction distribution of the lowest non-calm wind speed class.

4.3.2.2 Joint Frequency Distribution

The data for a particular historical period are summarized by developing a joint frequency distribution (JFD). Each such distribution specifies the fraction of time during the historical period that the following jointly occur:

- Wind speed within a particular range (wind speed class).
- Downwind direction in one of the 16 sectors corresponding to the 16 principal compass directions (N, NNE, etc.).
- Atmospheric conditions corresponding to one of the seven atmospheric stability classes discussed in Section 4.3.2. Tables 4-8 through 4-10 contain this data.

Different JFDs are associated with the different release classifications defined in Section 4.1.4. One JFD is defined for stack releases, and another JFD is defined for ground level releases. Two JFDs are associated with vent (mixed mode) releases, one for the portion of the time the release is treated as elevated and the other for the portion of the time the release is treated as ground level.

4.3.2.2.1 Downwind Direction Versus Upwind Direction

Unless otherwise noted, any reference to wind direction in this document represents downwind direction, i.e., the direction in which the wind is blowing toward. This is because the parameters developed in this document are used to calculate radioactivity concentration and radiation dose downwind of a release point. In contrast, it is conventional for meteorologists to provide JFDs based on upwind direction, the direction from which the wind is blowing. For example, the JFDs presented in the annual operating reports of the nuclear power stations are obtained from a meteorological contractor and the directions specified in the reports are upwind directions. Users of JFDs should always be careful to ascertain whether the directions specified are upwind or downwind.

4.3.2.2.2 Stack JFD

For a stack release, the JFD is defined as follows:

$f_s(n, \theta, c)$ Joint Frequency Distribution, Stack Release

The fraction of hours during a period of observation that all of the following hold:

- The average wind speed is within wind speed class n .
- The downwind direction is within the sector denoted by θ .
- The atmospheric stability class is c .

This function is defined for application to a stack release point (see Section 4.1.4). Its value is based on hourly average wind data obtained at a height representative of the release point height.

The stack JFD is normalized to 1:

$$\sum_{n, \theta, c} f_s(n, \theta, c) = 1 \quad (4-28)$$

4.3.2.2.3 Ground Level JFD

For a ground level release, the JFD $f_g(n, \theta, c)$ is defined in the same way as for a stack release except that the wind data are obtained at a height representative of a ground level release point. This height is taken as 35 feet.

The ground level JFD is normalized to 1:

$$\sum_{n, \theta, c} f_g(n, \theta, c) = 1 \quad (4-29)$$

4.3.2.2.4 Vent JFDs

In accordance with the approach recommended in Regulatory Guide 1.111 (Reference 7), the plume from a vent release is treated as elevated part of the time and as ground level the rest of the time. Two JFDs are determined:

- $f_{v,elev}(n, \theta, c)$ characterizes the plume during the part of the time that it is considered elevated;
- $f_{v,gnd}(n, \theta, c)$ characterizes the plume during the part of the time that it is considered ground level.

Their definitions are as follows:

$f_{v,elev}(n, \theta, c)$ Joint Frequency Distribution, Elevated Portion of a Vent Release

The fraction of hours during a period of observation that the plume is considered elevated and that all of the following hold:

- The average wind speed is within wind speed class n .
- The downwind direction is within the sector denoted by θ .
- The atmospheric stability class is c .

$f_{v,gnd}(n, \theta, c)$ Joint Frequency Distribution, Ground Level Portion of a Vent Release

The fraction of hours during a period of observation that the plume is considered ground level and that all of the following hold:

- The average wind speed is within wind speed class n .
- The downwind direction is within the sector denoted by θ .
- The atmospheric stability class is c .

The value of $f_{v,elev}(n, \theta, c)$ is based on hourly average wind data at a height representative of the vent release point. Where the measurement height differed considerably from the release height, wind speed data for the release height was obtained by extrapolation. The value of $f_{v,gnd}(n, \theta, c)$ is based on hourly average wind data obtained at a height representative of a ground level release point. This is taken as 35 feet.

The sum of these two JFDs is normalized to 1:

$$\sum_{n, \theta, c} (f_{v,elev}(n, \theta, c) + f_{v,gnd}(n, \theta, c)) = 1 \quad (4-30)$$

The prescription of Regulatory Guide 1.111 is used in determining the fraction of time that the plume is considered elevated and the fraction of time that it is considered ground level. The fractions are obtained from the ratio of stack exit velocity W_o to hourly average wind speed u at the height of the vent release point as follows:

- If $W_o / u > 5$, then the plume is considered elevated for the hour.
- If $W_o / u < 1$, then the plume is considered ground level for the hour.
- If $1 < W_o / u < 5$, the plume is considered to be a ground level release for a fraction G_t of the hour and an elevated release for a fraction $(1 - G_t)$ of the hour where G_t is defined as follows:

$$G_t = 2.58 - 1.58(W_o/u) \quad \text{for } 1.0 < W_o / u \leq 1.5 \quad (4-31)$$

$$G_t = 0.30 - 0.06(W_o/u) \quad \text{for } 1.5 < W_o / u \leq 5.0 \quad (4-32)$$

4.3.2.3 Average Wind Speed

Using the joint frequency distribution, average wind speeds are obtained for Dresden. Values are obtained for each downwind direction (N, NNE, etc.) and for various release point classifications (stack, vent, and ground level).

4.3.2.3.1 Stack Release

For a stack release, the following formula is used:

$$u_s(\theta) = \frac{\sum_{n,c} (f_s(n,\theta,c)u_n)}{\sum_{n,c} (f_s(n,\theta,c))} \quad (4-33)$$

- where: (units)
- $u_n(\theta)$ Average Wind Speed, Stack Release - The average wind speed in downwind direction θ for a stack release. [m/sec]
- u_n Wind Speed for Class n - A wind speed representative of wind speed class n . For each wind speed class except the highest, u_n is the average of the upper and lower limits of the wind speed range for the class. For the highest wind speed class, u_n is the lower limit of the wind speed range for the class. [m/sec]

The parameter f_s is defined in Section 4.3.2.2.2.

4.3.2.3.2 Ground Level Release

For a ground level release, the following formula is used:

$$u_g(\theta) = \frac{\sum_{n,c} (f_g(n, \theta, c) u_n)}{\sum_{n,c} (f_g(n, \theta, c))} \quad (4-34)$$

- where: (units)
- $u_g(\theta)$ Average Wind Speed, Ground Level Release - The average wind speed in downwind direction θ for a ground level release. [m/sec]
- u_n Wind Speed for Class n - A wind speed representative of wind speed class n . For each wind speed class except the highest, u_n is the average of the upper and lower limits of the wind speed range for the class. For the highest wind speed class, u_n is the lower limit of the wind speed range for the class. [m/sec]

The parameter f_g is defined in Section 4.3.2.2.3.

4.3.2.3.3 Vent Release

For a vent release, the following formula is used:

$$u_v(\theta) = \frac{\sum_{n,c} ((f_{v,elev}(n, \theta, c) + f_{v,gnd}(n, \theta, c)) u_n)}{\sum_{n,c} (f_{v,elev}(n, \theta, c) + f_{v,gnd}(n, \theta, c))} \quad (4-35)$$

- where: (units)
- $u_v(\theta)$ Average Wind Speed, Vent Release - The average wind speed in downwind direction θ for a vent release. [m/sec]
- u_n Wind Speed for Class n - A wind speed representative of wind speed class n . For each wind speed class except the highest, u_n is the average of the upper and lower limits of the wind speed range for the class. For the highest wind speed class, u_n is the lower limit of the wind speed range for the class. [m/sec]

The parameters $f_{v,elev}$ and $f_{v,gnd}$ are defined in Section 4.3.2.2.4.

4.3.3 Gaussian Plume Models

As a plume of airborne effluents moves away from an elevated release point, the plume both broadens and meanders. It has been found that the time-averaged distribution of material in an effluent plume can be well represented mathematically by a Gaussian function.

4.3.3.1 Mathematical Representation

In a widely used form of the Gaussian plume model, the distribution of radioactivity in a plume is represented mathematically by the equation below:

$$\chi(x, y, z) = \left(\frac{\dot{Q}}{2\pi\sigma_y\sigma_z u} \right) e^{-\frac{y^2}{2\sigma_y^2}} \times \left(e^{-\frac{(z-h_e)^2}{2\sigma_z^2}} + e^{-\frac{(z+h_e)^2}{2\sigma_z^2}} \right) \quad (4-36)$$

where:

| | | |
|----------------------|---|-------------------------------|
| | | (units) |
| $\chi(x, y, z)$ | Radioactivity Concentration - The concentration of radioactivity at point (x,y,z) , where: | [$\mu\text{Ci}/\text{m}^3$] |
| x | Downwind Distance - Distance from the stack along an axis parallel to the wind direction. | [m] |
| y | Crosswind Distance - Distance from the plume centerline along an axis parallel to the crosswind direction. | [m] |
| z | Vertical Distance - Distance from the ground (grade level at the stack) along an axis parallel to the vertical direction. | [m] |
| \dot{Q} | Release Rate - Release rate of radioactivity. | [$\mu\text{Ci}/\text{sec}$] |
| σ_y, σ_z | Horizontal and Vertical Dispersion Coefficients - Standard deviations of the Gaussian distributions describing the plume cross-sections in the y and z directions, respectively. The values of σ_y and σ_z depend on several parameters: <ul style="list-style-type: none"> • Downwind distance x. Because a plume broadens and meanders as it travels away from its release point, the values of σ_y and σ_z increase as x increases. • Atmospheric stability class. The plume is broadest for extremely unstable atmospheric conditions (Class A) and narrowest for extremely stable conditions (Class G). • Time period of averaging plume concentration. The values of σ_y and σ_z increase as the averaging period increases. | [m] |
| u | Average Wind Speed - The average wind speed. The average speed of travel of the plume in the x direction. | [m/sec] |
| h_e | Effective Release Height - The effective height of effluent release above grade elevation, which may be greater than the actual release height (see Section 4.3.4.1.1.1). | [m] |

The two exponential functions of **z** in Equation 4-36 represent the emitted and reflected components of the plume. The reflected component (represented by the exponential with **(z + h_e)** in its argument) arises from the assumption that all material in a portion of the plume that touches ground is reflected upward. This assumption is conservative if one is calculating airborne radioactivity concentration.

4.3.3.2 Sector-Averaged Concentration

Sometimes, it is desired to determine the average concentration of radioactivity in a sector due to release at a constant rate over an extended period of time (e.g., a year). For such a case, it is reasonable to assume that the wind blows with equal likelihood toward all directions within the sector. From Equation 4-36, the following equation for ground level radioactivity concentration can be derived:

$$\chi_{\text{sector}} = \left(\frac{2.032 f \dot{Q}}{\sigma_z u x} \right) e^{-\frac{h_s^2}{2\sigma_z^2}} \quad (4-37)$$

where:

χ_{sector} Sector-Averaged Ground Level Concentration - The time-averaged concentration of airborne radioactivity in a sector at ground level at a distance x from the release point. (units) [$\mu\text{Ci}/\text{m}^3$]

2.032 $\sqrt{\frac{2}{\pi}}$ divided by the width in radians of a 22.5° sector (or $\frac{\pi}{8}$), (Reference 7) dimensionless.

f Sector Fraction - The fraction of time that the wind blows into the sector, dimensionless.

The other parameter definitions are the same as for Equation 4-36.

4.3.4 Relative Concentration Factor χ/Q

The relative concentration factor χ/Q (called "chi over Q") provides a simplified method of calculating the radioactivity concentration at a given point in an effluent plume when the release rate is known:

$$\chi = \dot{Q} \left(\frac{\chi}{Q} \right) \quad (4-38)$$

| | | |
|-----------|--|-----------------------------|
| where: | | (units) |
| χ | Concentration of Radioactivity - Concentration of radioactivity at point (x,y,z) in the atmosphere. | $[\mu\text{Ci}/\text{m}^3]$ |
| \dot{Q} | Release Rate - Release rate of radioactivity. | $[\mu\text{Ci}/\text{sec}]$ |
| χ/Q | Relative Concentration Factor - Relative concentration factor for point (x,y,z) . The airborne radioactivity concentration at (x,y,z) per unit release rate. | $[\text{sec}/\text{m}^3]$ |

Expressions for χ/Q based on Gaussian plume models can be obtained from the equations for concentration χ in Section 4.3.3 simply by dividing both sides of each equation by the release rate. For example, from Equation 4-37, we obtain the following expression for the sector-averaged χ/Q :

$$\chi_{\text{sector}} / \dot{Q} = \left(\frac{2.032 f}{\sigma_z u x} \right) e^{-\frac{h_e^2}{2\sigma_z^2}} \quad (4-39)$$

The values of χ/Q used in ODCM calculations are both sector-averaged and time-averaged. The time averaging is based on the historical average atmospheric conditions of a specified multi-year time period (see Section 4.3.2) and is accomplished by use of the joint frequency distribution discussed in Section 4.3.2.2. The formulas used to obtain the time- and sector-averaged χ/Q are based on Equation 4-39, but vary depending on whether the release is a stack, ground level, or vent release. The three cases are discussed below.

4.3.4.1 Stack Release

For a stack release, the relative concentration factor is designated $(\chi/Q)_s$. Its value is obtained by the following formula:

$$\left(\frac{\chi}{Q}\right)_s = \frac{2.032}{R} \sum_{n,c} \left(f_s(n, \theta, c) \left(\frac{e^{-\frac{h_e^2}{2\sigma_z^2}}}{u_n \sigma_z} \right) \right) \quad (4-40)$$

where:

| | | |
|---------------------------------|---|-----------------------|
| | | (units) |
| $\left(\frac{\chi}{Q}\right)_s$ | Relative Concentration Factor, Stack Release - The time- and sector-averaged relative concentration factor due to a stack release for a point at ground level at distance R in downwind direction θ . | [sec/m ³] |
| 2.032 | $\sqrt{\frac{2}{\pi}}$ divided by the width in radians of a 22.5° sector ($\frac{\pi}{8}$), (Reference 7) dimensionless. | |
| R | Radius - Downwind distance from the release point to the point of interest. | [m] |
| $f_s(n, \theta, c)$ | Joint Frequency Distribution, Stack Release, defined in Section 4.3.2.2.2, dimensionless. | |
| h_e | Effective Release Height - The effective height of an effluent release above grade elevation. For a stack release, h_e is obtained by correcting the actual height of the release point for plume rise, terrain effects, and downwash as described in Section 4.3.4.1.1, below. | [m] |
| σ_z | Standard Vertical Dispersion Coefficient - A coefficient characterizing vertical plume spread in the Gaussian model for stability class c at radius R (see Table 4-17). | [m] |
| u_n | Wind Speed - A wind speed representative of wind speed class n . For each wind speed class except the highest, u_n is the average of the upper and lower limits of the wind speed range for the class. For the highest wind speed class, u_n is the lower limit of the wind speed range for the class. | [m/sec] |

This expression is recommended by the NRC in Regulatory Guide 1.111 (Reference 7) and is based on a model designated there as the "constant mean wind direction model." In this model it is assumed that the mean wind speed, the mean wind direction, and the atmospheric stability class determined at the release point also apply at all points within the region in which airborne concentration is being evaluated.

4.3.4.1.1 Effective Release Height

For a stack release, the effective height of an effluent plume is the height of the release point corrected for plume rise and terrain effects:

$$\text{If } (h_s + h_{pr} - h_t) < 100 \text{ meters, then } h_e = h_s + h_{pr} - h_t \quad (4-41)$$

$$\text{If } (h_s + h_{pr} - h_t) \geq 100 \text{ meters, then } h_e = 100 \text{ meters} \quad (4-42)$$

| | |
|--|---------|
| where: | (units) |
| h_e Effective Release Height - The effective height of an effluent release above grade elevation. | [m] |
| h_s Actual Release Height - The actual height of the release above grade elevation. | [m] |
| h_{pr} Plume Rise - The rise of the plume due to its momentum and buoyancy. (See Section 4.3.4.1.1.1) | [m] |
| h_t Terrain Correction Parameter - A parameter to account for the effect of terrain elevation on the effective height of a plume. Taken as zero (see Section 4.3.4.1.1.2). | [m] |

4.3.4.1.1.1 Plume Rise

Because nuclear power stations generally have plumes that are not significantly warmer than room temperature, plume rise due to buoyancy is neglected. The formulas used to calculate plume rise due to momentum are given below.

Stability Classes A, B, C, and D

For these stability classes (corresponding to unstable and neutral conditions), h_{pr} is taken as the lesser of two quantities:

$$h_{pr} = \text{Minimum of } [(h_{pr})_1, (h_{pr})_2] \quad (4-43)$$

$$(h_{pr})_1 = (1.44) \left(\sqrt[3]{\left(\frac{W_o}{u}\right)^2} \right) \left(\sqrt[3]{\frac{R}{d}} \right) d - c \quad (h_{pr})_2 = 3 \left(1.5 - \frac{W_o}{u} \right) d \quad (4-44), (4-45)$$

| | |
|---|---------|
| where: | (units) |
| W_o Stack Exit Velocity - The effluent stream velocity at the discharge point. | [m/sec] |
| u Wind Speed | [m/sec] |
| R Radius - Downwind distance from the release point to the point of interest. | [m] |
| d Internal Stack Diameter - The internal diameter of the stack from which the effluent is released. | [m] |
| c Downwash Correction - A parameter to account for downwash at low exit velocities, where: | [m] |

$$c = 3 \left(1.5 - \frac{W_o}{u} \right) d \text{ if } W_o < 1.5u \quad (4-46)$$

$$c = 0 \text{ if } W_o \geq 1.5u \quad (4-47)$$

Note that $(h_{pr})_1$ can increase without limit as R increases; thus, the effect of $(h_{pr})_2$ is to limit calculated plume rise at large distances from the nuclear power station.

Stability Classes E, F, and G

For these stability classes (corresponding to stable conditions), h_{pr} is taken as the minimum of four quantities:

$$h_{pr} = \text{Minimum of } [(h_{pr})_1, (h_{pr})_2, (h_{pr})_3, (h_{pr})_4] \quad (4-48)$$

$$(h_{pr})_3 = (4) \sqrt[4]{\frac{F}{S}} \quad (4-49)$$

$$(h_{pr})_4 = (1.5) \sqrt[3]{\frac{F}{u}} \sqrt[6]{\frac{1}{S}} \quad (4-50)$$

where:

F Momentum Flux Parameter, defined as:

(units)

[m⁴/sec²]

$$F = W_o^2 \left(\frac{d}{2} \right)^2 \quad (4-51)$$

S Stability Parameter, defined as:

[sec⁻²]

| Stability Class | S |
|-----------------|---------|
| E | 8.70E-4 |
| F | 1.75E-3 |
| G | 2.45E-3 |

u Wind Speed

[m/sec]

The quantities $(h_{pr})_1$ and $(h_{pr})_2$ are as defined by Equations 4-44 and 4-45.

4.3.4.1.1.2 Terrain Effects

Due to general flatness of the terrain in the vicinity of Dresden, the terrain correction parameter h_t was taken as zero in all calculations of meteorological dispersion and dose parameters for this Manual.

4.3.4.2 Ground Level Release

For a ground level release, the relative concentration factor is designated $(\chi/Q)_g$. Its value is obtained by the following formula:

$$\left(\frac{\chi}{Q}\right)_g = \frac{2.032}{R} \sum_{n,c} \left(\frac{f_g(n, \theta, c)}{u_n S_z} \right) \quad (4-52)$$

where: (units)

$\left(\frac{\chi}{Q}\right)_g$ Relative Concentration Factor, Ground Level Release - The time- and sector-averaged relative concentration factor due to a ground level release for a point at ground level at distance **R** in downwind direction θ . [sec/m³]

$f_g(n, \theta, c)$ Joint Frequency Distribution, Ground Level Release, defined in Section 4.3.2.2.3, dimensionless.

S_z Wake-Corrected Vertical Dispersion Coefficient - The vertical dispersion coefficient corrected for building wake effects. The correction is made as described below. [m]

The remaining parameters are defined in Section 4.3.4.1.

Wake-Corrected Vertical Dispersion Coefficient

The wake-corrected vertical dispersion coefficient S_z in Equation 4-52 is taken as the lesser of two quantities:

$$S_z = \text{Minimum of } [(S_z)_1, (S_z)_2] \quad (4-53)$$

$$(S_z)_1 = \sqrt{\sigma_z^2 + \frac{D^2}{2\pi}} \quad (4-54)$$

$$(S_z)_2 = \sigma_z \sqrt{3} \quad (4-55)$$

where: (units)

S_z Wake-Corrected Vertical Dispersion Coefficient - The vertical dispersion coefficient corrected for building wake effects. [m]

σ_z Standard Vertical Dispersion Coefficient - The coefficient characterizing vertical plume spread in the Gaussian model for stability class **c** at distance **R** (see Table 4-17). [m]

D Maximum Height of Neighboring Structure - The maximum height of any neighboring structure causing building wake effects (see Table 4-11). [m]

4.3.4.3 Vent Release

For a vent release, the relative concentration factor is designated $(\chi/Q)_v$. Its value is obtained by the following formula:

$$\left(\frac{\chi}{Q}\right)_v = \frac{2.032}{R} \sum_{n,c} \left(\frac{f_{v,elev}(n,\theta,c)}{u_n \sigma_z} e^{-\frac{h_0^2}{2\sigma_z^2}} + \frac{f_{v,gnd}(n,\theta,c)}{u_n S_z} \right) \quad (4-56)$$

where:

$\left(\frac{\chi}{Q}\right)_v$ Relative Concentration Factor, Vent Release - The time- and sector-averaged relative concentration factor due to a vent release for a point at ground level at distance **R** in downwind direction θ . [sec/m³]

The parameters $f_{v,elev}(n,\theta,c)$ and $f_{v,gnd}(n,\theta,c)$ are defined in Section 4.3.2.2.4. The parameter S_z is defined in Section 4.3.4.2. The remaining parameters are defined in Section 4.3.4.1.

4.3.4.4 Removal Mechanisms

In Regulatory Guide 1.111, the NRC allows various removal mechanisms to be considered in evaluating the radiological impact of airborne effluents. These include radioactive decay, dry deposition, wet deposition, and deposition over water. For simplicity, these removal mechanisms cited by the NRC are not accounted for in the evaluation or use of χ/Q in this Manual. This represents a conservative approximation as ignoring removal mechanisms increases the value of χ/Q .

4.3.5 Relative Deposition Factor D/Q

The quantity **D/Q** (called "D over Q") is defined to provide the following simple way of calculating the rate of deposition of radioactivity at a given point on the ground when the release rate is known.

$$\dot{d} = \dot{Q} \left(\frac{D}{Q}\right) \quad (4-57)$$

where:

\dot{d} Deposition Rate - Rate of deposition of radioactivity at a specified point on the ground. [(μ Ci/m²)/sec]

\dot{Q} Release Rate of radioactivity. [μ Ci/sec]

$\left(\frac{D}{Q}\right)$ Relative Deposition Factor - Relative deposition factor for a specified point on the ground. The deposition rate per unit release rate. [m⁻²]

The values of **D/Q** used in this manual are time-averaged. The time averaging is based on the historical average atmospheric conditions of a specified multi-year time period (see Section 4.3.2) and is accomplished by use of the joint frequency distribution described in Section 4.3.2.2. The formulas used to obtain **D/Q** vary depending on whether the release is a stack, ground level, or vent release. The three cases are discussed below.

4.3.5.1 Stack Release

For a stack release, the relative deposition factor is designated $(D/Q)_s$. Its value is obtained by the following formula:

$$\left(\frac{D}{Q}\right)_s = \frac{16}{2\pi R} \sum_{n,c} (f_s(n, \theta, c) D_r(c, R, h_e)) \quad (4-58)$$

| | | |
|----------------------|--|------------|
| where: | | (units) |
| $(D/Q)_s$ | Relative Deposition Factor, Stack Release - The time-averaged relative deposition factor due to a stack release for a point at distance R in the direction θ . | $[m^{-2}]$ |
| $2\pi/16$ | Sector Width - The width of a sector over which the plume direction is assumed to be uniformly distributed (as in the model of Section 4.3.3.2). Taken as 1/16 of a circle, inverted in the equation. | [radian] |
| R | Radius - Downwind distance from the release point to the point of interest. | [m] |
| $f_s(n, \theta, c)$ | Joint Frequency Distribution, Stack Release, defined in Section 4.3.2.2.2, dimensionless. | |
| $D_r(c, R, h_e)$ | Relative Deposition Rate, Stack Release - The deposition rate per unit downwind distance [$\mu Ci/(sec \cdot m)$] divided by the source strength [$\mu Ci/sec$] due to a stack release for stability class c , downwind distance R , and effective release height h_e . The value is based on Figures 7 to 9 of Regulatory Guide 1.111, which apply, respectively, to release heights of 30, 60, and 100 m. Linear interpolation is used to obtain values at intermediate release heights. If the effective release height is greater than 100 meters, then the data for 100 meters are used. | $[m^{-1}]$ |
| h_e | Effective Release Height - The effective height of an effluent release above grade elevation. | [m] |

4.3.5.2 Ground Level Release

For ground level release, the relative deposition factor is designated $(D/Q)_g$. Its value is obtained by the following formula:

$$\left(\frac{D}{Q}\right)_g = \frac{16}{2\pi R} D_r(R) \sum_{n,c} (f_g(n, \theta, c)) \quad (4-59)$$

where: (units)

$(D/Q)_g$ Relative Deposition Factor, Ground Level Release - The time-averaged relative deposition factor due to a ground level release for a point at distance R in the direction θ . $[m^{-2}]$

$f_g(n, \theta, c)$ Joint Frequency Distribution, Ground Level Release, defined in Section 4.3.2.2.3, dimensionless.

$D_r(R)$ Relative Deposition Rate, Ground Level - The deposition rate per unit downwind distance [$\mu Ci/(sec \cdot m)$] divided by the source strength [$\mu Ci/sec$] due to a ground level release for downwind distance R . The value is taken from Figure 6 of Regulatory Guide 1.111 and is the same for all atmospheric stability classes. $[m^{-1}]$

The remaining parameters are defined in Section 4.3.5.1.

4.3.5.3 Vent Release

For a vent release, the relative deposition factor is designated $(D/Q)_v$. Its value is obtained by the following formula:

$$\left(\frac{D}{Q}\right)_v = \frac{16}{2\pi R} \left(\sum_{n,c} (f_{v,elev}(n, \theta, c) D_r(c, R, h_e)) + D_r(R) \sum_{n,c} (f_{v,gnd}(n, \theta, c)) \right) \quad (4-60)$$

where: (units)

$(D/Q)_v$ Relative Deposition Factor, Vent Release - The time-averaged relative deposition factor due to a ground level release for a point at distance R in the direction θ . $[m^{-2}]$

The parameters $f_{v,elev}(n, \theta, c)$ and $f_{v,gnd}(n, \theta, c)$ are defined in Section 4.3.2.2.4. The remaining parameters are defined in Sections 4.3.5.1 and 4.3.5.2.

4.3.6 Gamma Air Dose Factors (S_i , V_i , G_i)

The gamma air dose factors provide a simple way of calculating doses and dose rates to air due to gamma radiation. For example, using a dose factor DF_i , gamma air dose rate may be calculated as follows:

$$\dot{D} = \sum_i \dot{D}_i \quad (4-61)$$

$$\dot{D} = \sum_i (\dot{Q}_i DF_i) \quad (4-62)$$

where:

| | (units) |
|---|-----------------------------|
| \dot{D} Gamma Air Dose Rate - The gamma air dose rate due to all radionuclides released. | [mrad/yr] |
| \dot{D}_i Gamma Air Dose Rate Due to Radionuclide i | [mrad/yr] |
| \dot{Q}_i Release Rate of Radionuclide i | [μ Ci/sec] |
| DF_i Gamma Air Dose Factor for Radionuclide i - A factor used to calculate gamma air dose or dose rate due to release of radionuclide i . Gamma air dose rate at a particular location per unit release rate. | [(mrad/yr)/(μ Ci/sec)] |

Three gamma air dose factors are defined: S_i , V_i , and G_i . They are used for stack, vent, and ground level releases, respectively. These three release point classifications are defined in Section 4.1.4. The calculation of the three dose factors is discussed below.

4.3.6.1 Stack Release

For a stack release, the gamma air dose factor S_i is obtained by a model similar to that of Equation 6 of Regulatory Guide 1.109 (Reference 6). A sector-averaged Gaussian plume is assumed and the dose factor is evaluated on the basis of historical average atmospheric conditions. The value of S_i depends on distance R from the release point and on downwind sector θ .

The following equation is used:

$$S_i = 260 \frac{16}{2\pi R} \sum_{n,c,k} \left(f_s(n, \theta, c) \left(e^{-\frac{\lambda_i R}{3600 u_n}} \right) \frac{E_k \mu_a(E_k) A_{ki}(h_e, u_n, c, \sigma_z, E_k)}{u_n} \right) \quad (4-63)$$

where:

| | (units) |
|--|---|
| S_i Gamma Air Dose Factor, Stack Release - The gamma air dose factor at ground level for a stack release for radionuclide i , downwind sector θ , downwind distance R from the release point, and the average atmospheric conditions of a specified historical time period. | [(mrad/yr)/(μ Ci/sec)] |
| 260 Conversion factor to reconcile units of Equation 4-63. | [(mrad-radians- m ³ -disintegrations) /(sec-MeV-Ci)] |

| | | |
|-------------------|---|------------------------------|
| $2\pi/16$ | Sector Width - The width of a sector over which the plume direction is assumed to be uniformly distributed (as in the model of Section 4.3.3.2). Taken as 1/16 of a circle, inverted in the equation. | [radian] |
| $f_s(n,\theta,c)$ | Joint Frequency Distribution, Stack Release, defined in Section 4.3.2.2.2, dimensionless. | |
| λ_i | Radiological Decay Constant for radionuclide i . See Table 1-6. | [hr ⁻¹] |
| 3600 | Conversion factor to m/hr from m/sec. | [sec/hr] |
| E_k | Photon Group Energy - An energy representative of photon energy group k . The photons emitted by each radionuclide are grouped into energy groups in order to facilitate analysis. All photons with energy in energy group k are assumed to have energy E_k . | [MeV/photon] |
| $\mu_a(E_k)$ | Air Energy Absorption Coefficient - The linear energy absorption coefficient for air for photon energy group k . The fraction of energy absorbed in air per unit of distance traveled for a beam of photons of energy E_k . Distance is measured in units of linear thickness (meters). | [m ⁻¹] |
| A_{ki} | Effective Photon Yield - The effective number of photons emitted with energy in energy group k per decay of nuclide i . The parameter A_{ki} is calculated on the basis of Section B.1 of Regulatory Guide 1.109 (Reference 6), where: | [photons per disintegration] |
| | $A_{ki} = \frac{\sum_m (A_m E_m \mu_a(E_m))}{E_k \mu_a(E_k)}$ | (4-64) |
| A_m | True Photon Yield - The actual number of photons emitted with energy E_m per decay of nuclide i . | [photons per disintegration] |
| E_m | Photon Energy - The energy of the m^{th} photon within photon energy group k . | [MeV/photon] |
| $\mu_a(E_m)$ | Air Energy Absorption Coefficient - The linear energy absorption coefficient for air for photon energy E_m . | [m ⁻¹] |
| $I(\dots)$ | <p>I Function - A parameter obtained by numerical evaluation of integrals that arise in the plume gamma dose problem. The value of I depends on the arguments (...) listed in the equation. A specific definition for I is given by Equation F-13 of Regulatory Guide 1.109. The integrals involved in calculating I arise from conceptually dividing up the radioactive plume into small elements of radioactivity and adding up the doses produced at the point of interest by all of the small elements. The distribution of radioactivity in the plume is represented by a sector-averaged Gaussian plume model like that discussed in Section 4.3.3.2, dimensionless.</p> <p>The parameters R, h_e, u_n, and σ_z are defined in Section 4.3.4.1.</p> | |

4.3.6.2 Ground Level Release

The gamma air dose factor G_i for a ground level release is defined as follows:

$$G_i = 260 \frac{16}{2\pi R} \sum_{n,c,k} \left(f_g(n,\theta,c) \left(e^{-\frac{\lambda_i R}{3600 u_n}} \right) \frac{E_k \mu_a(E_k) A_{ki}(h_e, u_n, c, \sigma_z, E_k)}{u_n} \right) \quad (4-65)$$

where:

(units)

G_i Gamma Air Dose Factor, Ground Level Release - The gamma air dose factor at ground level for a ground level release for radionuclide i , downwind sector θ , downwind distance R from the release point, and the average atmospheric conditions of a specified historical time period. [(mrad/yr)/(\muCi/sec)]

The parameter $f_g(n,\theta,c)$ is defined in Section 4.3.2.2.3.

In evaluating the I function, the effective release height h_e is taken as zero.

The remaining parameters are defined in Section 4.3.6.1.

This corresponds to use of a finite plume model.

4.3.6.3 Vent Release

For a vent release, the gamma air dose factor is calculated as follows:

$$V_i = 260 \frac{16}{2\pi R} \sum_{n,c,k} \left(f_{v,elev}(n,\theta,c) \left(e^{-\frac{\lambda_i R}{3600 u_n}} \right) \frac{E_k \mu_a(E_k) A_{ki}(h_e, u_n, c, \sigma_z, E_k)}{u_n} + f_{v,gnd}(n,\theta,c) \left(e^{-\frac{\lambda_i R}{3600 u_n}} \right) \frac{E_k \mu_a(E_k) A_{ki}(h_e, u_n, c, \sigma_z, E_k)}{u_n} \right) \quad (4-66)$$

where:

(units)

V_i Gamma Air Dose Factor, Vent Release - The gamma air dose factor at ground level for a vent release for radionuclide i , downwind sector θ , downwind distance R from the release point, and the average atmospheric conditions of a specified historical time period. [(mrad/yr)/(\muCi/sec)]

The parameters $f_{v,elev}(n,\theta,c)$ and $f_{v,gnd}(n,\theta,c)$ are defined in Section 4.3.2.2.4.

In evaluating the I function, the effective release height h_e is taken as zero for the ground level release term.

The remaining parameters are defined in Section 4.3.6.1.

4.3.7 Gamma Total Body Dose Factors $\bar{S}_i, \bar{V}_i, \bar{G}_i$

The gamma total body dose factors are used to calculate doses and dose rates due to gamma irradiation of the total body. They are similar to the gamma air dose factors (see the discussion at the beginning of Section 4.3.6). The gamma total body dose factors are defined for stack, vent, and ground level releases, respectively.

4.3.7.1 Stack Release

To obtain the gamma total body dose factor for a stack release, Equation 4-63 is modified to account for the attenuation of gamma radiation by 1 cm of tissue with a density of 1 g/cm³. The following expression results:

$$\bar{S}_i = 260 \frac{16}{2\pi R} \sum_{n,c,k} \left(f_s(n, \theta, c) \left(e^{-\frac{\lambda_i R}{3600 u_n}} \right) \frac{E_k \mu_a(E_k) A_{ki} I(h_e, u_n, c, \sigma_z, E_k)}{u_n} e^{-\mu_a^T(E_k) t_d} \right) \quad (4-67)$$

where:

| | (units) |
|----------------|---|
| \bar{S}_i | Gamma Total Body Dose Factor, Stack Release - The gamma total body dose factor at ground level for a stack release for radionuclide i, downwind sector θ , downwind distance R from the release point, and the average atmospheric conditions of a specified historical time period. [(mrad/yr)/(μ Ci/sec)] |
| $\mu_a^T(E_k)$ | Tissue Energy Absorption Coefficient - The mass energy absorption coefficient for tissue for photon energy group k. The fraction of energy absorbed in tissue per unit distance of travel for a beam of photons of energy E_k with a distance measured in units of density thickness (g/cm ²). [cm ² /g] |
| t_d | Tissue Thickness - An assumed value of tissue thickness used in calculating total body dose. Taken as 1 g/cm ² to represent 1 cm of tissue with a density of 1 g/cm ³ . Accounts for the shielding of the inner, more radiosensitive parts of the body by the outer body parts. [g/cm ²] |

The remaining parameters are defined in Section 4.3.6.1.

4.3.7.2 Ground Level Release

To obtain the gamma total body dose factor for a ground level release, Equation 4-65 is modified to account for the attenuation of gamma radiation by 1 cm of tissue with a density of 1 g/cm³. The following expression results:

$$\bar{G}_i = 260 \frac{16}{2\pi R} \sum_{n,c,k} \left(f_g(n, \theta, c) \left(e^{-\frac{\lambda_p R}{3600 u_n}} \right) \frac{E_k \mu_a(E_k) A_{ki} I(h_e, u_n, c, \sigma_z, E_k)}{u_n} e^{-\mu_a^T(E_k) t_d} \right) \quad (4-68)$$

Where:

(units)

\bar{G}_i Gamma Total Body Dose Factor, Ground Level Release - The gamma total body dose factor at ground level for a ground level release for radionuclide i, downwind sector θ , downwind distance R from the release point, and the average atmospheric conditions of a specified historical time period. [(mrad/yr)/(μ Ci/sec)]

The factors $\mu_a^T(E_k)$ and t_d are defined in Section 4.3.7.1.

In evaluating the I function, the effective release height h_e is taken as zero.

The remaining parameters are defined in Section 4.3.6.1.

4.3.7.3 Vent Release

To obtain the gamma total body dose factor for a vent release, Equation 4-66 is modified to account for the attenuation of gamma radiation by 1 cm of tissue with a density of 1 g/cm³. The following expression results:

$$\bar{V}_i = 260 \frac{16}{2\pi R} \sum_{n,c,k} \left(\begin{aligned} & f_{v, elev}(n, \theta, c) \left(e^{-\frac{\lambda_p R}{3600 u_n}} \right) \frac{E_k \mu_a(E_k) A_{ki} I(h_e, u_n, c, \sigma_z, E_k)}{u_n} e^{-\mu_a^T(E_k) t_d} \\ & + f_{v, gnd}(n, \theta, c) \left(e^{-\frac{\lambda_p R}{3600 u_n}} \right) \frac{E_k \mu_a(E_k) A_{ki} I(h_e, u_n, c, \sigma_z, E_k)}{u_n} e^{-\mu_a^T(E_k) t_d} \end{aligned} \right) \quad (4-69)$$

Where:

(units)

\bar{V}_i Gamma Total Body Dose Factor, Vent Release - The gamma total body dose factor at ground level for a stack release for radionuclide i, downwind sector θ , downwind distance R from the release point, and the average atmospheric conditions of a specified historical time period. [(mrad/yr)/(μ Ci/sec)]

The factors $\mu_a^T(E_k)$ and t_d are defined in Section 4.3.7.1.

In evaluating the I function, the effective release height h_e is taken as zero for the ground level release term.

The remaining parameters are defined in Section 4.3.6.1.

Table 4-1
Critical Ranges

| Direction | Site Boundary ^a (m) | Restricted Area Boundary (m) | Nearest Resident ^b (m) | Nearest Dairy Farm Within 5 Miles ^c (m) |
|-----------|-----------------------------------|---------------------------------|--------------------------------------|---|
| N | 768 | 466 | 2609 | None |
| NNE | 1207 | 698 | 1399 | None |
| NE | 1100 | 646 | 1419 | None |
| ENE | 1244 | 646 | 1438 | None |
| E | 1000 | 689 | 1874 | None |
| ESE | 988 | 661 | 1560 | None |
| SE | 1000 | 664 | 1008 | None |
| SSE | 792 | 744 | 868 | None |
| S | 841 | 814 | 875 | None |
| SSW | 853 | 789 | 5017 | None |
| SW | 1024 | 414 | 6398 | None |
| WSW | 1170 | 360 | 9434 | None |
| W | 1756 | 454 | 4971 | None |
| WNW | 1219 | 469 | 6846 | None |
| NW | 756 | 482 | 3826 | None |
| NNW | 671 | 466 | 1645 | None |

^a Nearest land outside the site boundary. Used in calculating the meteorological dose factors in Tables 4-3 and 4-6.

^b By GPS survey (when available) or satellite mapping. Data current as of the 2007 Land Use Census.

^c 2007 annual milch animal census. Used in calculating the D/Q values in Table 4-5, with a default value of 8000 meters used when there are no dairies within 5 miles.

Table 4-2
Average Wind Speeds for Dresden 1, 2, and 3

| Downwind Direction | Average Wind Speed (m/sec) ^a | | |
|--------------------|---|------------|--------------|
| | Elevated | Mixed Mode | Ground Level |
| N | 7.3 | 5.5 | 4.3 |
| NNE | 7.4 | 5.3 | 4.1 |
| NE | 6.9 | 5.0 | 3.7 |
| ENE | 6.4 | 4.9 | 4.0 |
| E | 7.1 | 5.3 | 4.1 |
| ESE | 7.2 | 5.3 | 4.1 |
| SE | 6.4 | 5.1 | 3.7 |
| SSE | 6.4 | 4.8 | 3.4 |
| S | 5.9 | 4.4 | 3.1 |
| SSW | 5.9 | 4.5 | 3.0 |
| SW | 5.7 | 4.4 | 3.0 |
| WSW | 5.1 | 4.0 | 2.8 |
| W | 5.5 | 4.4 | 3.2 |
| WNW | 5.9 | 4.4 | 3.0 |
| NW | 5.7 | 4.4 | 3.4 |
| NNW | 6.3 | 4.9 | 3.8 |

^a Based on Dresden site meteorological data, January 1978 through December 1987. Calculated in "Verification of Environmental Parameters Used for Commonwealth Edison Company's Offsite Dose Calculation," NUS Corporation, 1988 (Unit 1) and "CECo ODCM Appendix F Tables for Dresden 2/3," Sargent & Lundy, Analysis and Technology Division, Dresden Calculation ATD-0145, Revision 0, 1 and 2 (Units 2/3).

Table 4-3
X/Q and D/Q Maxima At or Beyond the Site Boundary

| Downwind Direction | Elevated (Stack) Release | | | | Mixed Mode (Vent) Release | | | Ground Level Release | | |
|--------------------|--------------------------|--|-----------------|---------------------------------------|---------------------------|--|---------------------------------------|----------------------|--|---------------------------------------|
| | Radius (meters) | (X/Q) _s (sec/m ³) | Radius (meters) | (D/Q) _s (m ⁻²) | Radius (meters) | (X/Q) _v (sec/m ³) | (D/Q) _v (m ⁻²) | Radius (meters) | (X/Q) _g (sec/m ³) | (D/Q) _g (m ⁻²) |
| N | 4400 | 1.470E-08 | 768 | 8.955E-10 | 768 | 4.752E-07 | 6.331E-09 | 768 | 3.363E-06 | 1.840E-08 |
| NNE | 4023 | 1.502E-08 | 1207 | 8.387E-10 | 1207 | 2.440E-07 | 3.028E-09 | 1207 | 1.565E-06 | 8.011E-09 |
| NE | 4400 | 1.231E-08 | 1100 | 7.495E-10 | 1100 | 2.409E-07 | 2.716E-09 | 1100 | 1.805E-06 | 7.715E-09 |
| ENE | 4023 | 1.100E-08 | 1244 | 6.629E-10 | 1244 | 1.370E-07 | 1.982E-09 | 1244 | 8.865E-07 | 4.617E-09 |
| E | 3600 | 1.517E-08 | 1000 | 1.036E-09 | 1000 | 3.326E-07 | 4.215E-09 | 1000 | 1.983E-06 | 1.114E-08 |
| ESE | 3600 | 1.417E-08 | 988 | 1.104E-09 | 988 | 2.741E-07 | 3.956E-09 | 988 | 1.914E-06 | 1.042E-08 |
| SE | 3600 | 1.350E-08 | 1000 | 1.111E-09 | 1000 | 2.357E-07 | 3.527E-09 | 1000 | 2.027E-06 | 9.865E-09 |
| SSE | 3219 | 1.298E-08 | 792 | 1.257E-09 | 792 | 2.876E-07 | 4.369E-09 | 792 | 2.725E-06 | 1.248E-08 |
| S | 4023 | 9.552E-09 | 841 | 8.039E-10 | 841 | 1.891E-07 | 2.719E-09 | 841 | 2.060E-06 | 8.371E-09 |
| SSW | 4023 | 9.123E-09 | 853 | 7.329E-10 | 853 | 1.900E-07 | 2.436E-09 | 853 | 1.923E-06 | 7.879E-09 |
| SW | 4400 | 1.085E-08 | 1024 | 6.659E-10 | 1024 | 1.538E-07 | 1.887E-09 | 1024 | 1.639E-06 | 6.659E-09 |
| WSW | 4400 | 1.232E-08 | 1170 | 6.123E-10 | 1170 | 1.207E-07 | 1.339E-09 | 1170 | 1.162E-06 | 4.615E-09 |
| W | 4828 | 1.105E-08 | 1756 | 4.566E-10 | 1756 | 1.190E-07 | 1.028E-09 | 1756 | 7.763E-07 | 3.122E-09 |
| WNW | 4828 | 8.765E-09 | 1219 | 4.387E-10 | 1219 | 1.833E-07 | 1.685E-09 | 1219 | 1.798E-06 | 6.402E-09 |
| NW | 4828 | 9.337E-09 | 756 | 5.904E-10 | 756 | 2.478E-07 | 2.791E-09 | 756 | 2.391E-06 | 1.070E-08 |
| NNW | 4400 | 1.083E-08 | 671 | 6.750E-10 | 671 | 4.310E-07 | 5.167E-09 | 671 | 3.546E-06 | 1.901E-08 |

Dresden Site Meteorological Data 1/78 – 12/87

Notes: Based on "CECo ODCM Appendix F Tables for Dresden 2/3," Sargent & Lundy, Analysis and Technology Division, Dresden Calculation ATD-0145, Revision 0, 1 and 2 (Units 2/3).

X/Q is used for beta air, beta skin, and inhalation dose pathways. See sections 4.2.2, 4.2.1, and 4.2.3.2.

D/Q is used for produce and leafy vegetable pathways. See section 4.2.3.

Radius is the approximate distance from midpoint between gaseous effluent release points to location of highest X/Q or D/Q at or beyond the site boundary.

Table 4-4

χ/Q and D/Q Maxima At or Beyond the Restricted Area Boundary

| Downwind Direction | Elevated (Stack) Release | | | | Mixed Mode (Vent) Release | | | Ground Level Release | | |
|--------------------|--------------------------|------------------------------------|-----------------|------------------------------|---------------------------|------------------------------------|------------------------------|----------------------|------------------------------------|------------------------------|
| | Radius (meters) | $(\chi/Q)_s$ (sec/m ³) | Radius (meters) | $(D/Q)_s$ (m ⁻²) | Radius (meters) | $(\chi/Q)_v$ (sec/m ³) | $(D/Q)_v$ (m ⁻²) | Radius (meters) | $(\chi/Q)_g$ (sec/m ³) | $(D/Q)_g$ (m ⁻²) |
| N | 4400 | 1.470E-08 | 466 | 1.046E-09 | 466 | 9.968E-07 | 1.232E-08 | 466 | 7.375E-06 | 4.036E-08 |
| NNE | 4023 | 1.502E-08 | 698 | 1.051E-09 | 698 | 5.152E-07 | 6.619E-09 | 698 | 3.645E-06 | 1.961E-08 |
| NE | 4400 | 1.231E-08 | 646 | 9.588E-10 | 646 | 5.276E-07 | 5.692E-09 | 646 | 4.202E-06 | 1.827E-08 |
| ENE | 4023 | 1.100E-08 | 646 | 8.886E-10 | 646 | 3.461E-07 | 4.918E-09 | 646 | 2.474E-06 | 1.345E-08 |
| E | 3600 | 1.517E-08 | 689 | 1.217E-09 | 689 | 5.525E-07 | 7.074E-09 | 689 | 3.492E-06 | 2.040E-08 |
| ESE | 3600 | 1.417E-08 | 661 | 1.341E-09 | 661 | 4.830E-07 | 6.936E-09 | 661 | 3.564E-06 | 1.997E-08 |
| SE | 3600 | 1.350E-08 | 664 | 1.385E-09 | 664 | 4.187E-07 | 6.112E-09 | 664 | 3.877E-06 | 1.916E-08 |
| SSE | 3219 | 1.298E-08 | 744 | 1.299E-09 | 744 | 3.153E-07 | 4.734E-09 | 744 | 3.016E-06 | 1.380E-08 |
| S | 4023 | 9.552E-09 | 814 | 8.181E-10 | 814 | 1.977E-07 | 2.834E-09 | 814 | 2.165E-06 | 8.827E-09 |
| SSW | 4023 | 9.123E-09 | 789 | 7.631E-10 | 789 | 2.111E-07 | 2.694E-09 | 789 | 2.169E-06 | 8.941E-09 |
| SW | 4400 | 1.085E-08 | 420 | 8.897E-10 | 414 | 5.193E-07 | 5.643E-09 | 414 | 6.356E-06 | 2.796E-08 |
| WSW | 4400 | 1.232E-08 | 420 | 7.963E-10 | 360 | 5.431E-07 | 5.055E-09 | 360 | 7.095E-06 | 2.980E-08 |
| W | 4828 | 1.105E-08 | 454 | 6.582E-10 | 454 | 5.736E-07 | 5.881E-09 | 454 | 5.859E-06 | 2.829E-08 |
| WNW | 4828 | 8.765E-09 | 469 | 6.124E-10 | 469 | 7.098E-07 | 5.907E-09 | 469 | 8.176E-06 | 2.969E-08 |
| NW | 4828 | 9.337E-09 | 482 | 6.915E-10 | 482 | 4.885E-07 | 4.835E-09 | 482 | 4.860E-06 | 2.173E-08 |
| NNW | 4400 | 1.083E-08 | 466 | 7.491E-10 | 466 | 7.327E-07 | 8.268E-09 | 466 | 6.214E-06 | 3.358E-08 |

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Table 4-5

D/Q at the Nearest Milk Cow and Meat Animal Locations within 5 miles

| Downwind Direction | Nearest Milk Cow D/Q (m ⁻²) | | | | Nearest Meat Animal D/Q (m ⁻²) | | | |
|--------------------|---|------------------|---------------|----------------|--|------------------|---------------|----------------|
| | Radius (meters) | Elevated Release | Mixed Release | Ground Release | Radius (meters) | Elevated Release | Mixed Release | Ground Release |
| N | 8000 | 1.073E-10 | 1.533E-10 | 3.231E-10 | 2300 | 5.089E-10 | 1.232E-09 | 2.916E-09 |
| NNE | 8000 | 1.103E-10 | 1.411E-10 | 2.954E-10 | 8000 | 1.103E-10 | 1.411E-10 | 2.954E-10 |
| NE | 8000 | 9.092E-11 | 1.115E-10 | 2.434E-10 | 8000 | 9.092E-11 | 1.115E-10 | 2.434E-10 |
| ENE | 8000 | 8.435E-11 | 9.923E-11 | 1.792E-10 | 8000 | 8.435E-11 | 9.923E-11 | 1.792E-10 |
| E | 8000 | 1.282E-10 | 1.521E-10 | 3.011E-10 | 8000 | 1.282E-10 | 1.521E-10 | 3.011E-10 |
| ESE | 8000 | 1.241E-10 | 1.363E-10 | 2.759E-10 | 8000 | 1.241E-10 | 1.363E-10 | 2.759E-10 |
| SE | 8000 | 1.146E-10 | 1.308E-10 | 2.665E-10 | 8000 | 1.146E-10 | 1.308E-10 | 2.665E-10 |
| SSE | 8000 | 1.126E-10 | 1.213E-10 | 2.303E-10 | 8000 | 1.126E-10 | 1.213E-10 | 2.303E-10 |
| S | 8000 | 7.758E-11 | 8.690E-11 | 1.703E-10 | 8000 | 7.758E-11 | 8.690E-11 | 1.703E-10 |
| SSW | 8000 | 7.408E-11 | 7.845E-11 | 1.640E-10 | 8000 | 7.408E-11 | 7.845E-11 | 1.640E-10 |
| SW | 8000 | 8.618E-11 | 8.357E-11 | 1.870E-10 | 8000 | 8.618E-11 | 8.357E-11 | 1.870E-10 |
| WSW | 8000 | 9.051E-11 | 7.512E-11 | 1.615E-10 | 8000 | 9.051E-11 | 7.512E-11 | 1.615E-10 |
| W | 8000 | 7.826E-11 | 9.150E-11 | 2.177E-10 | 800 | 5.665E-10 | 2.944E-09 | 1.160E-08 |
| WNW | 8000 | 5.945E-11 | 8.480E-11 | 2.401E-10 | 800 | 5.121E-10 | 3.015E-09 | 1.280E-08 |
| NW | 8000 | 6.284E-11 | 7.514E-11 | 1.832E-10 | 800 | 5.753E-10 | 2.596E-09 | 9.768E-09 |
| NNW | 8000 | 7.599E-11 | 1.095E-10 | 2.688E-10 | 1600 | 5.010E-10 | 1.505E-09 | 4.520E-09 |

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Note: Based on "CECo ODCM Appendix F Tables for Dresden 2/3," Sargent & Lundy, Analysis and Technology Division, Dresden Calculation ATD-0145, Revision 0, 1 and 2 (Units 2/3).

If there is no actual milk or meat producer within 5 miles of the station, one is assumed to be located at 8000 m.

Table 4-6 (Page 1 of 15)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Site Boundary for Kr-83m

| Downwind Direction | Site Boundary (meters) | Elevated (Stack) Release | | | Mixed Mode (Vent) Release | | | Ground Level Release | | |
|--------------------|---------------------------|--------------------------|--------------------------|----------------------------------|---------------------------|--------------------------|----------------------------------|----------------------|--------------------------|----------------------------------|
| | | Radius (meters) | S (mrad/yr)/(μCi/sec) | \bar{S} (mrad/yr)/(μCi/sec) | Radius (meters) | V (mrad/yr)/(μCi/sec) | \bar{V} (mrad/yr)/(μCi/sec) | Radius (meters) | G (mrad/yr)/(μCi/sec) | \bar{G} (mrad/yr)/(μCi/sec) |
| N | 768 | 768 | 1.111E-06 | 8.377E-07 | 768 | 5.804E-05 | 4.377E-05 | 768 | 3.601E-04 | 2.715E-04 |
| NNE | 1207 | 1207 | 1.254E-06 | 9.453E-07 | 1207 | 2.901E-05 | 2.188E-05 | 1207 | 1.645E-04 | 1.240E-04 |
| NE | 1100 | 1100 | 1.062E-06 | 8.010E-07 | 1100 | 2.861E-05 | 2.157E-05 | 1100 | 1.855E-04 | 1.399E-04 |
| ENE | 1244 | 1244 | 1.018E-06 | 7.677E-07 | 1244 | 1.595E-05 | 1.202E-05 | 1244 | 8.930E-05 | 6.733E-05 |
| E | 1000 | 1000 | 1.301E-06 | 9.808E-07 | 1000 | 3.900E-05 | 2.941E-05 | 1000 | 2.092E-04 | 1.577E-04 |
| ESE | 988 | 988 | 1.336E-06 | 1.007E-06 | 988 | 3.237E-05 | 2.441E-05 | 988 | 2.005E-04 | 1.512E-04 |
| SE | 1000 | 1000 | 1.414E-06 | 1.066E-06 | 1000 | 2.828E-05 | 2.133E-05 | 1000 | 2.078E-04 | 1.567E-04 |
| SSE | 792 | 792 | 1.538E-06 | 1.160E-06 | 792 | 3.462E-05 | 2.610E-05 | 792 | 2.798E-04 | 2.110E-04 |
| S | 841 | 841 | 1.095E-06 | 8.259E-07 | 841 | 2.335E-05 | 1.761E-05 | 841 | 2.124E-04 | 1.601E-04 |
| SSW | 853 | 853 | 1.009E-06 | 7.606E-07 | 853 | 2.332E-05 | 1.759E-05 | 853 | 1.978E-04 | 1.491E-04 |
| SW | 1024 | 1024 | 8.474E-07 | 6.389E-07 | 1024 | 1.920E-05 | 1.448E-05 | 1024 | 1.648E-04 | 1.243E-04 |
| WSW | 1170 | 1170 | 8.268E-07 | 6.234E-07 | 1170 | 1.520E-05 | 1.146E-05 | 1170 | 1.147E-04 | 8.650E-05 |
| W | 1756 | 1756 | 8.303E-07 | 6.261E-07 | 1756 | 1.322E-05 | 9.966E-06 | 1756 | 7.461E-05 | 5.626E-05 |
| WNW | 1219 | 1219 | 6.944E-07 | 5.236E-07 | 1219 | 2.191E-05 | 1.652E-05 | 1219 | 1.789E-04 | 1.349E-04 |
| NW | 756 | 756 | 7.464E-07 | 5.628E-07 | 756 | 3.036E-05 | 2.289E-05 | 756 | 2.549E-04 | 1.922E-04 |
| NNW | 671 | 671 | 7.749E-07 | 5.843E-07 | 671 | 5.274E-05 | 3.977E-05 | 671 | 3.846E-04 | 2.900E-04 |

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Notes: Based on Sargent & Lundy, Nuclear Safeguards and Licensing Division, Calculation, "Appendix I Technical Specification Tables," Revision 2, July 10, 1979 and "CECo ODCM Appendix F Tables for Dresden 2/3," Sargent & Lundy, Analysis and Technology Division, Dresden Calculation ATD-0145, Revision 0, 1 and 2 (Units 2/3).

Table 4-6 (Page 2 of 15)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Site Boundary for Kr-85m

| Downwind Direction | Site Boundary (meters) | Elevated (Stack) Release | | | Mixed Mode (Vent) Release | | | Ground Level Release | | |
|--------------------|---------------------------|--------------------------|--------------------------|----------------------------------|---------------------------|--------------------------|----------------------------------|----------------------|--------------------------|----------------------------------|
| | | Radius (meters) | S (mrad/yr)/(μCi/sec) | \bar{S} (mrad/yr)/(μCi/sec) | Radius (meters) | V (mrad/yr)/(μCi/sec) | \bar{V} (mrad/yr)/(μCi/sec) | Radius (meters) | G (mrad/yr)/(μCi/sec) | \bar{G} (mrad/yr)/(μCi/sec) |
| N | 768 | 768 | 1.399E-04 | 1.354E-04 | 768 | 6.020E-04 | 5.795E-04 | 768 | 1.896E-03 | 1.815E-03 |
| NNE | 1207 | 1207 | 9.359E-05 | 9.053E-05 | 1207 | 3.303E-04 | 3.181E-04 | 1207 | 9.659E-04 | 9.257E-04 |
| NE | 1100 | 1100 | 9.061E-05 | 8.765E-05 | 1100 | 3.296E-04 | 3.175E-04 | 1100 | 1.053E-03 | 1.009E-03 |
| ENE | 1244 | 1244 | 7.359E-05 | 7.118E-05 | 1244 | 2.088E-04 | 2.012E-04 | 1244 | 5.484E-04 | 5.257E-04 |
| E | 1000 | 1000 | 1.064E-04 | 1.030E-04 | 1000 | 4.299E-04 | 4.140E-04 | 1000 | 1.216E-03 | 1.165E-03 |
| ESE | 988 | 988 | 9.782E-05 | 9.462E-05 | 988 | 3.568E-04 | 3.436E-04 | 988 | 1.154E-03 | 1.106E-03 |
| SE | 1000 | 1000 | 9.428E-05 | 9.118E-05 | 1000 | 3.260E-04 | 3.140E-04 | 1000 | 1.186E-03 | 1.136E-03 |
| SSE | 792 | 792 | 1.046E-04 | 1.012E-04 | 792 | 3.889E-04 | 3.745E-04 | 792 | 1.497E-03 | 1.433E-03 |
| S | 841 | 841 | 8.695E-05 | 8.411E-05 | 841 | 3.045E-04 | 2.934E-04 | 841 | 1.207E-03 | 1.156E-03 |
| SSW | 853 | 853 | 8.163E-05 | 7.896E-05 | 853 | 2.929E-04 | 2.823E-04 | 853 | 1.118E-03 | 1.071E-03 |
| SW | 1024 | 1024 | 7.425E-05 | 7.182E-05 | 1024 | 2.735E-04 | 2.637E-04 | 1024 | 1.008E-03 | 9.664E-04 |
| WSW | 1170 | 1170 | 7.278E-05 | 7.041E-05 | 1170 | 2.394E-04 | 2.309E-04 | 1170 | 7.281E-04 | 6.982E-04 |
| W | 1756 | 1756 | 4.764E-05 | 4.607E-05 | 1756 | 1.734E-04 | 1.671E-04 | 1756 | 5.186E-04 | 4.977E-04 |
| WNW | 1219 | 1219 | 5.560E-05 | 5.379E-05 | 1219 | 2.513E-04 | 2.420E-04 | 1219 | 1.060E-03 | 1.016E-03 |
| NW | 756 | 756 | 9.757E-05 | 9.441E-05 | 756 | 3.808E-04 | 3.669E-04 | 756 | 1.353E-03 | 1.295E-03 |
| NNW | 671 | 671 | 1.240E-04 | 1.200E-04 | 671 | 5.578E-04 | 5.371E-04 | 671 | 1.955E-03 | 1.871E-03 |

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Table 4-6 (Page 3 of 15)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Site Boundary for Kr-85

| Downwind Direction | Site Boundary (meters) | Elevated (Stack) Release | | | Mixed Mode (Vent) Release | | | Ground Level Release | | |
|--------------------|---------------------------|--------------------------|--------------------------|----------------------------------|---------------------------|--------------------------|----------------------------------|----------------------|--------------------------|----------------------------------|
| | | Radius (meters) | S (mrad/yr)/(μCi/sec) | \bar{S} (mrad/yr)/(μCi/sec) | Radius (meters) | V (mrad/yr)/(μCi/sec) | \bar{V} (mrad/yr)/(μCi/sec) | Radius (meters) | G (mrad/yr)/(μCi/sec) | \bar{G} (mrad/yr)/(μCi/sec) |
| N | 768 | 768 | 1.955E-06 | 1.890E-06 | 768 | 6.993E-06 | 6.763E-06 | 768 | 2.088E-05 | 2.019E-05 |
| NNE | 1207 | 1207 | 1.281E-06 | 1.239E-06 | 1207 | 3.867E-06 | 3.740E-06 | 1207 | 1.077E-05 | 1.041E-05 |
| NE | 1100 | 1100 | 1.253E-06 | 1.212E-06 | 1100 | 3.897E-06 | 3.768E-06 | 1100 | 1.187E-05 | 1.147E-05 |
| ENE | 1244 | 1244 | 1.020E-06 | 9.860E-07 | 1244 | 2.489E-06 | 2.407E-06 | 1244 | 6.226E-06 | 6.021E-06 |
| E | 1000 | 1000 | 1.472E-06 | 1.424E-06 | 1000 | 5.039E-06 | 4.873E-06 | 1000 | 1.354E-05 | 1.309E-05 |
| ESE | 988 | 988 | 1.348E-06 | 1.304E-06 | 988 | 4.188E-06 | 4.050E-06 | 988 | 1.287E-05 | 1.245E-05 |
| SE | 1000 | 1000 | 1.300E-06 | 1.257E-06 | 1000 | 3.825E-06 | 3.698E-06 | 1000 | 1.330E-05 | 1.286E-05 |
| SSE | 792 | 792 | 1.448E-06 | 1.400E-06 | 792 | 4.575E-06 | 4.424E-06 | 792 | 1.663E-05 | 1.608E-05 |
| S | 841 | 841 | 1.240E-06 | 1.199E-06 | 841 | 3.624E-06 | 3.504E-06 | 841 | 1.358E-05 | 1.313E-05 |
| SSW | 853 | 853 | 1.157E-06 | 1.119E-06 | 853 | 3.469E-06 | 3.354E-06 | 853 | 1.252E-05 | 1.210E-05 |
| SW | 1024 | 1024 | 1.047E-06 | 1.012E-06 | 1024 | 3.279E-06 | 3.170E-06 | 1024 | 1.141E-05 | 1.104E-05 |
| WSW | 1170 | 1170 | 1.022E-06 | 9.885E-07 | 1170 | 2.863E-06 | 2.769E-06 | 1170 | 8.279E-06 | 8.006E-06 |
| W | 1756 | 1756 | 6.701E-07 | 6.480E-07 | 1756 | 2.062E-06 | 1.994E-06 | 1756 | 5.967E-06 | 5.770E-06 |
| WNW | 1219 | 1219 | 7.759E-07 | 7.503E-07 | 1219 | 2.953E-06 | 2.856E-06 | 1219 | 1.208E-05 | 1.168E-05 |
| NW | 756 | 756 | 1.375E-06 | 1.330E-06 | 756 | 4.511E-06 | 4.362E-06 | 756 | 1.501E-05 | 1.451E-05 |
| NNW | 671 | 671 | 1.750E-06 | 1.692E-06 | 671 | 6.521E-06 | 6.306E-06 | 671 | 2.132E-05 | 2.062E-05 |

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Table 4-6 (Page 4 of 15)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Site Boundary for Kr-87

| Downwind Direction | Site Boundary (meters) | Elevated (Stack) Release | | | Mixed Mode (Vent) Release | | | Ground Level Release | | |
|--------------------|---------------------------|--------------------------|--------------------------|----------------------------------|---------------------------|--------------------------|----------------------------------|----------------------|--------------------------|----------------------------------|
| | | Radius (meters) | S (mrad/yr)/(μCi/sec) | \bar{S} (mrad/yr)/(μCi/sec) | Radius (meters) | V (mrad/yr)/(μCi/sec) | \bar{V} (mrad/yr)/(μCi/sec) | Radius (meters) | G (mrad/yr)/(μCi/sec) | \bar{G} (mrad/yr)/(μCi/sec) |
| N | 768 | 768 | 6.917E-04 | 6.720E-04 | 768 | 2.070E-03 | 2.010E-03 | 768 | 5.546E-03 | 5.385E-03 |
| NNE | 1207 | 1207 | 4.420E-04 | 4.294E-04 | 1207 | 1.116E-03 | 1.084E-03 | 1207 | 2.791E-03 | 2.710E-03 |
| NE | 1100 | 1100 | 4.363E-04 | 4.239E-04 | 1100 | 1.116E-03 | 1.083E-03 | 1100 | 2.958E-03 | 2.872E-03 |
| ENE | 1244 | 1244 | 3.520E-04 | 3.419E-04 | 1244 | 7.110E-04 | 6.905E-04 | 1244 | 1.547E-03 | 1.502E-03 |
| E | 1000 | 1000 | 5.151E-04 | 5.004E-04 | 1000 | 1.453E-03 | 1.411E-03 | 1000 | 3.526E-03 | 3.423E-03 |
| ESE | 988 | 988 | 4.711E-04 | 4.577E-04 | 988 | 1.210E-03 | 1.176E-03 | 988 | 3.332E-03 | 3.236E-03 |
| SE | 1000 | 1000 | 4.545E-04 | 4.416E-04 | 1000 | 1.122E-03 | 1.089E-03 | 1000 | 3.382E-03 | 3.283E-03 |
| SSE | 792 | 792 | 5.140E-04 | 4.994E-04 | 792 | 1.351E-03 | 1.312E-03 | 792 | 4.329E-03 | 4.203E-03 |
| S | 841 | 841 | 4.278E-04 | 4.157E-04 | 841 | 1.065E-03 | 1.034E-03 | 841 | 3.397E-03 | 3.298E-03 |
| SSW | 853 | 853 | 4.031E-04 | 3.916E-04 | 853 | 1.018E-03 | 9.886E-04 | 853 | 3.178E-03 | 3.086E-03 |
| SW | 1024 | 1024 | 3.642E-04 | 3.538E-04 | 1024 | 9.449E-04 | 9.177E-04 | 1024 | 2.821E-03 | 2.739E-03 |
| WSW | 1170 | 1170 | 3.548E-04 | 3.447E-04 | 1170 | 8.290E-04 | 8.051E-04 | 1170 | 2.035E-03 | 1.976E-03 |
| W | 1756 | 1756 | 2.211E-04 | 2.148E-04 | 1756 | 5.761E-04 | 5.595E-04 | 1756 | 1.444E-03 | 1.402E-03 |
| WNW | 1219 | 1219 | 2.687E-04 | 2.610E-04 | 1219 | 8.507E-04 | 8.261E-04 | 1219 | 2.919E-03 | 2.834E-03 |
| NW | 756 | 756 | 4.925E-04 | 4.785E-04 | 756 | 1.328E-03 | 1.289E-03 | 756 | 3.891E-03 | 3.778E-03 |
| NNW | 671 | 671 | 6.252E-04 | 6.074E-04 | 671 | 1.931E-03 | 1.875E-03 | 671 | 5.808E-03 | 5.639E-03 |

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Table 4-6 (Page 5 of 15)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Site Boundary for Kr-88

| Downwind Direction | Site Boundary (meters) | Elevated (Stack) Release | | | Mixed Mode (Vent) Release | | | Ground Level Release | | |
|--------------------|---------------------------|--------------------------|--------------------------|-----------|---------------------------|--------------------------|-----------|----------------------|--------------------------|-----------|
| | | Radius (meters) | S (mrad/yr)/(μCi/sec) | \bar{S} | Radius (meters) | V (mrad/yr)/(μCi/sec) | \bar{V} | Radius (meters) | G (mrad/yr)/(μCi/sec) | \bar{G} |
| N | 768 | 768 | 1.798E-03 | 1.750E-03 | 768 | 5.062E-03 | 4.922E-03 | 768 | 1.364E-02 | 1.325E-02 |
| NNE | 1207 | 1207 | 1.145E-03 | 1.115E-03 | 1207 | 2.773E-03 | 2.696E-03 | 1207 | 6.973E-03 | 6.774E-03 |
| NE | 1100 | 1100 | 1.134E-03 | 1.104E-03 | 1100 | 2.790E-03 | 2.713E-03 | 1100 | 7.521E-03 | 7.305E-03 |
| ENE | 1244 | 1244 | 9.211E-04 | 8.966E-04 | 1244 | 1.790E-03 | 1.741E-03 | 1244 | 3.954E-03 | 3.841E-03 |
| E | 1000 | 1000 | 1.337E-03 | 1.301E-03 | 1000 | 3.603E-03 | 3.504E-03 | 1000 | 8.777E-03 | 8.526E-03 |
| ESE | 988 | 988 | 1.221E-03 | 1.189E-03 | 988 | 3.006E-03 | 2.923E-03 | 988 | 8.327E-03 | 8.089E-03 |
| SE | 1000 | 1000 | 1.180E-03 | 1.149E-03 | 1000 | 2.775E-03 | 2.699E-03 | 1000 | 8.529E-03 | 8.284E-03 |
| SSE | 792 | 792 | 1.333E-03 | 1.297E-03 | 792 | 3.341E-03 | 3.250E-03 | 792 | 1.079E-02 | 1.048E-02 |
| S | 841 | 841 | 1.141E-03 | 1.110E-03 | 841 | 2.653E-03 | 2.580E-03 | 841 | 8.637E-03 | 8.389E-03 |
| SSW | 853 | 853 | 1.067E-03 | 1.038E-03 | 853 | 2.528E-03 | 2.458E-03 | 853 | 8.010E-03 | 7.780E-03 |
| SW | 1024 | 1024 | 9.589E-04 | 9.335E-04 | 1024 | 2.381E-03 | 2.316E-03 | 1024 | 7.206E-03 | 7.000E-03 |
| WSW | 1170 | 1170 | 9.327E-04 | 9.079E-04 | 1170 | 2.083E-03 | 2.026E-03 | 1170 | 5.217E-03 | 5.068E-03 |
| W | 1756 | 1756 | 5.907E-04 | 5.749E-04 | 1756 | 1.464E-03 | 1.424E-03 | 1756 | 3.745E-03 | 3.638E-03 |
| WNW | 1219 | 1219 | 7.062E-04 | 6.874E-04 | 1219 | 2.122E-03 | 2.063E-03 | 1219 | 7.530E-03 | 7.314E-03 |
| NW | 756 | 756 | 1.283E-03 | 1.249E-03 | 756 | 3.288E-03 | 3.198E-03 | 756 | 9.693E-03 | 9.414E-03 |
| NNW | 671 | 671 | 1.627E-03 | 1.584E-03 | 671 | 4.738E-03 | 4.608E-03 | 671 | 1.410E-02 | 1.369E-02 |

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Table 4-6 (Page 6 of 15)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Site Boundary for Kr-89

| Downwind Direction | Site Boundary (meters) | Elevated (Stack) Release | | | Mixed Mode (Vent) Release | | | Ground Level Release | | |
|--------------------|------------------------|--------------------------|-----------------------|-------------------------------|---------------------------|-----------------------|-------------------------------|----------------------|-----------------------|-------------------------------|
| | | Radius (meters) | S (mrad/yr)/(μCi/sec) | \bar{S} (mrad/yr)/(μCi/sec) | Radius (meters) | V (mrad/yr)/(μCi/sec) | \bar{V} (mrad/yr)/(μCi/sec) | Radius (meters) | G (mrad/yr)/(μCi/sec) | \bar{G} (mrad/yr)/(μCi/sec) |
| N | 768 | 768 | 8.646E-04 | 8.402E-04 | 768 | 2.184E-03 | 2.122E-03 | 768 | 3.839E-03 | 3.729E-03 |
| NNE | 1207 | 1207 | 4.473E-04 | 4.346E-04 | 1207 | 7.989E-04 | 7.761E-04 | 1207 | 1.144E-03 | 1.111E-03 |
| NE | 1100 | 1100 | 4.367E-04 | 4.243E-04 | 1100 | 8.040E-04 | 7.811E-04 | 1100 | 1.199E-03 | 1.165E-03 |
| ENE | 1244 | 1244 | 2.952E-04 | 2.869E-04 | 1244 | 4.535E-04 | 4.405E-04 | 1244 | 5.737E-04 | 5.573E-04 |
| E | 1000 | 1000 | 5.470E-04 | 5.316E-04 | 1000 | 1.225E-03 | 1.190E-03 | 1000 | 1.926E-03 | 1.871E-03 |
| ESE | 988 | 988 | 5.116E-04 | 4.972E-04 | 988 | 1.030E-03 | 1.000E-03 | 988 | 1.737E-03 | 1.687E-03 |
| SE | 1000 | 1000 | 4.765E-04 | 4.631E-04 | 1000 | 9.283E-04 | 9.017E-04 | 1000 | 1.559E-03 | 1.514E-03 |
| SSE | 792 | 792 | 6.139E-04 | 5.966E-04 | 792 | 1.268E-03 | 1.231E-03 | 792 | 2.376E-03 | 2.308E-03 |
| S | 841 | 841 | 4.316E-04 | 4.195E-04 | 841 | 8.997E-04 | 8.740E-04 | 841 | 1.470E-03 | 1.428E-03 |
| SSW | 853 | 853 | 4.106E-04 | 3.990E-04 | 853 | 8.384E-04 | 8.145E-04 | 853 | 1.447E-03 | 1.405E-03 |
| SW | 1024 | 1024 | 3.383E-04 | 3.288E-04 | 1024 | 6.604E-04 | 6.415E-04 | 1024 | 1.090E-03 | 1.059E-03 |
| WSW | 1170 | 1170 | 2.800E-04 | 2.721E-04 | 1170 | 4.872E-04 | 4.732E-04 | 1170 | 6.582E-04 | 6.393E-04 |
| W | 1756 | 1756 | 1.180E-04 | 1.147E-04 | 1756 | 2.232E-04 | 2.168E-04 | 1756 | 2.784E-04 | 2.704E-04 |
| WNW | 1219 | 1219 | 2.179E-04 | 2.118E-04 | 1219 | 5.131E-04 | 4.984E-04 | 1219 | 9.315E-04 | 9.048E-04 |
| NW | 756 | 756 | 5.630E-04 | 5.471E-04 | 756 | 1.241E-03 | 1.206E-03 | 756 | 2.287E-03 | 2.221E-03 |
| NNW | 671 | 671 | 7.830E-04 | 7.610E-04 | 671 | 2.075E-03 | 2.016E-03 | 671 | 4.479E-03 | 4.350E-03 |

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Table 4-6 (Page 7 of 15)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Site Boundary for Kr-90

| Downwind Direction | Site Boundary | Elevated (Stack) Release | | | Mixed Mode (Vent) Release | | | Ground Level Release | | |
|--------------------|---------------|--------------------------|---------------------------|-----------|---------------------------|---------------------------|-----------|----------------------|---------------------------|-----------|
| | | Radius | S | \bar{S} | Radius | V | \bar{V} | Radius | G | \bar{G} |
| | (meters) | (meters) | (mrad/yr)/(μ Ci/sec) | | (meters) | (mrad/yr)/(μ Ci/sec) | | (meters) | (mrad/yr)/(μ Ci/sec) | |
| N | 768 | 768 | 1.568E-04 | 1.522E-04 | 768 | 2.579E-04 | 2.501E-04 | 768 | 2.558E-04 | 2.480E-04 |
| NNE | 1207 | 1207 | 3.689E-05 | 3.581E-05 | 1207 | 3.215E-05 | 3.118E-05 | 1207 | 2.553E-05 | 2.476E-05 |
| NE | 1100 | 1100 | 3.809E-05 | 3.697E-05 | 1100 | 3.434E-05 | 3.331E-05 | 1100 | 2.511E-05 | 2.435E-05 |
| ENE | 1244 | 1244 | 1.660E-05 | 1.611E-05 | 1244 | 1.571E-05 | 1.524E-05 | 1244 | 1.176E-05 | 1.141E-05 |
| E | 1000 | 1000 | 5.925E-05 | 5.751E-05 | 1000 | 7.864E-05 | 7.628E-05 | 1000 | 6.596E-05 | 6.396E-05 |
| ESE | 988 | 988 | 5.808E-05 | 5.637E-05 | 988 | 6.960E-05 | 6.751E-05 | 988 | 6.042E-05 | 5.858E-05 |
| SE | 1000 | 1000 | 4.406E-05 | 4.276E-05 | 1000 | 5.157E-05 | 5.003E-05 | 1000 | 4.271E-05 | 4.142E-05 |
| SSE | 792 | 792 | 8.809E-05 | 8.550E-05 | 792 | 1.063E-04 | 1.032E-04 | 792 | 8.990E-05 | 8.717E-05 |
| S | 841 | 841 | 4.794E-05 | 4.653E-05 | 841 | 5.718E-05 | 5.547E-05 | 841 | 4.271E-05 | 4.142E-05 |
| SSW | 853 | 853 | 4.498E-05 | 4.366E-05 | 853 | 5.154E-05 | 5.000E-05 | 853 | 3.559E-05 | 3.451E-05 |
| SW | 1024 | 1024 | 2.322E-05 | 2.254E-05 | 1024 | 2.362E-05 | 2.292E-05 | 1024 | 1.401E-05 | 1.359E-05 |
| WSW | 1170 | 1170 | 1.048E-05 | 1.018E-05 | 1170 | 8.515E-06 | 8.260E-06 | 1170 | 4.127E-06 | 4.002E-06 |
| W | 1756 | 1756 | 1.866E-06 | 1.811E-06 | 1756 | 1.530E-06 | 1.484E-06 | 1756 | 7.900E-07 | 7.660E-07 |
| WNW | 1219 | 1219 | 1.141E-05 | 1.108E-05 | 1219 | 1.162E-05 | 1.127E-05 | 1219 | 7.712E-06 | 7.478E-06 |
| NW | 756 | 756 | 7.050E-05 | 6.843E-05 | 756 | 9.619E-05 | 9.331E-05 | 756 | 9.617E-05 | 9.325E-05 |
| NNW | 671 | 671 | 1.395E-04 | 1.354E-04 | 671 | 2.516E-04 | 2.440E-04 | 671 | 3.058E-04 | 2.965E-04 |

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Table 4-6 (Page 8 of 15)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Site Boundary for Xe-131m

| Downwind Direction | Site Boundary (meters) | Elevated (Stack) Release | | | Mixed Mode (Vent) Release | | | Ground Level Release | | |
|--------------------|---------------------------|--------------------------|--------------------------|----------------------------------|---------------------------|--------------------------|----------------------------------|----------------------|--------------------------|----------------------------------|
| | | Radius (meters) | S (mrad/yr)/(μCi/sec) | \bar{S} (mrad/yr)/(μCi/sec) | Radius (meters) | V (mrad/yr)/(μCi/sec) | \bar{V} (mrad/yr)/(μCi/sec) | Radius (meters) | G (mrad/yr)/(μCi/sec) | \bar{G} (mrad/yr)/(μCi/sec) |
| N | 768 | 768 | 3.860E-06 | 3.549E-06 | 768 | 5.875E-05 | 4.699E-05 | 768 | 3.373E-04 | 2.627E-04 |
| NNE | 1207 | 1207 | 2.996E-06 | 2.686E-06 | 1207 | 3.052E-05 | 2.450E-05 | 1207 | 1.588E-04 | 1.241E-04 |
| NE | 1100 | 1100 | 2.780E-06 | 2.510E-06 | 1100 | 3.055E-05 | 2.453E-05 | 1100 | 1.832E-04 | 1.429E-04 |
| ENE | 1244 | 1244 | 2.389E-06 | 2.138E-06 | 1244 | 1.775E-05 | 1.433E-05 | 1244 | 9.009E-05 | 7.042E-05 |
| E | 1000 | 1000 | 3.301E-06 | 2.974E-06 | 1000 | 4.098E-05 | 3.284E-05 | 1000 | 2.011E-04 | 1.571E-04 |
| ESE | 988 | 988 | 3.141E-06 | 2.814E-06 | 988 | 3.367E-05 | 2.700E-05 | 988 | 1.935E-04 | 1.511E-04 |
| SE | 1000 | 1000 | 3.130E-06 | 2.790E-06 | 1000 | 2.958E-05 | 2.377E-05 | 1000 | 2.037E-04 | 1.589E-04 |
| SSE | 792 | 792 | 3.440E-06 | 3.070E-06 | 792 | 3.584E-05 | 2.877E-05 | 792 | 2.679E-04 | 2.087E-04 |
| S | 841 | 841 | 2.742E-06 | 2.468E-06 | 841 | 2.515E-05 | 2.034E-05 | 841 | 2.097E-04 | 1.636E-04 |
| SSW | 853 | 853 | 2.552E-06 | 2.299E-06 | 853 | 2.495E-05 | 2.014E-05 | 853 | 1.939E-04 | 1.512E-04 |
| SW | 1024 | 1024 | 2.264E-06 | 2.047E-06 | 1024 | 2.129E-05 | 1.730E-05 | 1024 | 1.655E-04 | 1.294E-04 |
| WSW | 1170 | 1170 | 2.221E-06 | 2.008E-06 | 1170 | 1.748E-05 | 1.427E-05 | 1170 | 1.168E-04 | 9.138E-05 |
| W | 1756 | 1756 | 1.707E-06 | 1.508E-06 | 1756 | 1.464E-05 | 1.183E-05 | 1756 | 7.787E-05 | 6.110E-05 |
| WNW | 1219 | 1219 | 1.748E-06 | 1.573E-06 | 1219 | 2.310E-05 | 1.855E-05 | 1219 | 1.829E-04 | 1.428E-04 |
| NW | 756 | 756 | 2.670E-06 | 2.458E-06 | 756 | 3.276E-05 | 2.642E-05 | 756 | 2.430E-04 | 1.892E-04 |
| NNW | 671 | 671 | 3.255E-06 | 3.020E-06 | 671 | 5.352E-05 | 4.285E-05 | 671 | 3.526E-04 | 2.744E-04 |

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Table 4-6 (Page 9 of 15)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Site Boundary for Xe-133m

| Downwind Direction | Site Boundary (meters) | Elevated (Stack) Release | | | Mixed Mode (Vent) Release | | | Ground Level Release | | |
|--------------------|---------------------------|--------------------------|--------------------------|----------------------------------|---------------------------|--------------------------|----------------------------------|----------------------|--------------------------|----------------------------------|
| | | Radius (meters) | S (mrad/yr)/(μCi/sec) | \bar{S} (mrad/yr)/(μCi/sec) | Radius (meters) | V (mrad/yr)/(μCi/sec) | \bar{V} (mrad/yr)/(μCi/sec) | Radius (meters) | G (mrad/yr)/(μCi/sec) | \bar{G} (mrad/yr)/(μCi/sec) |
| N | 768 | 768 | 2.077E-05 | 1.991E-05 | 768 | 1.316E-04 | 1.171E-04 | 768 | 5.699E-04 | 4.854E-04 |
| NNE | 1207 | 1207 | 1.432E-05 | 1.364E-05 | 1207 | 7.079E-05 | 6.329E-05 | 1207 | 2.781E-04 | 2.384E-04 |
| NE | 1100 | 1100 | 1.375E-05 | 1.312E-05 | 1100 | 7.088E-05 | 6.337E-05 | 1100 | 3.146E-04 | 2.689E-04 |
| ENE | 1244 | 1244 | 1.132E-05 | 1.078E-05 | 1244 | 4.336E-05 | 3.901E-05 | 1244 | 1.587E-04 | 1.362E-04 |
| E | 1000 | 1000 | 1.617E-05 | 1.542E-05 | 1000 | 9.343E-05 | 8.334E-05 | 1000 | 3.512E-04 | 3.009E-04 |
| ESE | 988 | 988 | 1.497E-05 | 1.425E-05 | 988 | 7.719E-05 | 6.890E-05 | 988 | 3.362E-04 | 2.878E-04 |
| SE | 1000 | 1000 | 1.453E-05 | 1.382E-05 | 1000 | 6.921E-05 | 6.194E-05 | 1000 | 3.510E-04 | 3.001E-04 |
| SSE | 792 | 792 | 1.607E-05 | 1.529E-05 | 792 | 8.308E-05 | 7.427E-05 | 792 | 4.526E-04 | 3.856E-04 |
| S | 841 | 841 | 1.335E-05 | 1.273E-05 | 841 | 6.223E-05 | 5.608E-05 | 841 | 3.601E-04 | 3.077E-04 |
| SSW | 853 | 853 | 1.248E-05 | 1.190E-05 | 853 | 6.060E-05 | 5.449E-05 | 853 | 3.327E-04 | 2.842E-04 |
| SW | 1024 | 1024 | 1.128E-05 | 1.077E-05 | 1024 | 5.478E-05 | 4.959E-05 | 1024 | 2.917E-04 | 2.504E-04 |
| WSW | 1170 | 1170 | 1.106E-05 | 1.056E-05 | 1170 | 4.676E-05 | 4.251E-05 | 1170 | 2.081E-04 | 1.790E-04 |
| W | 1756 | 1756 | 7.554E-06 | 7.162E-06 | 1756 | 3.599E-05 | 3.241E-05 | 1756 | 1.432E-04 | 1.239E-04 |
| WNW | 1219 | 1219 | 8.502E-06 | 8.106E-06 | 1219 | 5.377E-05 | 4.810E-05 | 1219 | 3.164E-04 | 2.707E-04 |
| NW | 756 | 756 | 1.446E-05 | 1.386E-05 | 756 | 7.908E-05 | 7.105E-05 | 756 | 4.100E-04 | 3.491E-04 |
| NNW | 671 | 671 | 1.823E-05 | 1.751E-05 | 671 | 1.211E-04 | 1.079E-04 | 671 | 5.909E-04 | 5.025E-04 |

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Table 4-6 (Page 10 of 15)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Site Boundary for Xe-133

| Downwind Direction | Site Boundary (meters) | Elevated (Stack) Release | | | Mixed Mode (Vent) Release | | | Ground Level Release | | |
|--------------------|---------------------------|--------------------------|--------------------------|----------------------------------|---------------------------|--------------------------|----------------------------------|----------------------|--------------------------|----------------------------------|
| | | Radius (meters) | S (mrad/yr)/(μCi/sec) | \bar{S} (mrad/yr)/(μCi/sec) | Radius (meters) | V (mrad/yr)/(μCi/sec) | \bar{V} (mrad/yr)/(μCi/sec) | Radius (meters) | G (mrad/yr)/(μCi/sec) | \bar{G} (mrad/yr)/(μCi/sec) |
| N | 768 | 768 | 1.874E-05 | 1.809E-05 | 768 | 1.481E-04 | 1.356E-04 | 768 | 6.304E-04 | 5.584E-04 |
| NNE | 1207 | 1207 | 1.362E-05 | 1.308E-05 | 1207 | 7.994E-05 | 7.347E-05 | 1207 | 3.114E-04 | 2.775E-04 |
| NE | 1100 | 1100 | 1.279E-05 | 1.230E-05 | 1100 | 7.969E-05 | 7.322E-05 | 1100 | 3.505E-04 | 3.114E-04 |
| ENE | 1244 | 1244 | 1.062E-05 | 1.019E-05 | 1244 | 4.887E-05 | 4.512E-05 | 1244 | 1.780E-04 | 1.588E-04 |
| E | 1000 | 1000 | 1.507E-05 | 1.448E-05 | 1000 | 1.055E-04 | 9.682E-05 | 1000 | 3.930E-04 | 3.500E-04 |
| ESE | 988 | 988 | 1.406E-05 | 1.350E-05 | 988 | 8.706E-05 | 7.992E-05 | 988 | 3.755E-04 | 3.341E-04 |
| SE | 1000 | 1000 | 1.367E-05 | 1.311E-05 | 1000 | 7.806E-05 | 7.179E-05 | 1000 | 3.909E-04 | 3.474E-04 |
| SSE | 792 | 792 | 1.491E-05 | 1.430E-05 | 792 | 9.314E-05 | 8.555E-05 | 792 | 5.002E-04 | 4.430E-04 |
| S | 841 | 841 | 1.201E-05 | 1.154E-05 | 841 | 6.991E-05 | 6.460E-05 | 841 | 4.011E-04 | 3.563E-04 |
| SSW | 853 | 853 | 1.126E-05 | 1.082E-05 | 853 | 6.822E-05 | 6.295E-05 | 853 | 3.704E-04 | 3.290E-04 |
| SW | 1024 | 1024 | 1.031E-05 | 9.919E-06 | 1024 | 6.164E-05 | 5.715E-05 | 1024 | 3.280E-04 | 2.926E-04 |
| WSW | 1170 | 1170 | 1.020E-05 | 9.811E-06 | 1170 | 5.274E-05 | 4.906E-05 | 1170 | 2.347E-04 | 2.097E-04 |
| W | 1756 | 1756 | 7.325E-06 | 7.009E-06 | 1756 | 4.041E-05 | 3.732E-05 | 1756 | 1.627E-04 | 1.460E-04 |
| WNW | 1219 | 1219 | 7.875E-06 | 7.566E-06 | 1219 | 6.054E-05 | 5.564E-05 | 1219 | 3.538E-04 | 3.147E-04 |
| NW | 756 | 756 | 1.282E-05 | 1.237E-05 | 756 | 8.885E-05 | 8.193E-05 | 756 | 4.536E-04 | 4.018E-04 |
| NNW | 671 | 671 | 1.609E-05 | 1.556E-05 | 671 | 1.356E-04 | 1.242E-04 | 671 | 6.514E-04 | 5.762E-04 |

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Table 4-6 (Page 11 of 15)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Site Boundary for Xe-135m

| Downwind Direction | Site Boundary (meters) | Elevated (Stack) Release | | | Mixed Mode (Vent) Release | | | Ground Level Release | | |
|--------------------|---------------------------|--------------------------|--------------------------|----------------------------------|---------------------------|--------------------------|----------------------------------|----------------------|--------------------------|----------------------------------|
| | | Radius (meters) | S (mrad/yr)/(μCi/sec) | \bar{S} (mrad/yr)/(μCi/sec) | Radius (meters) | V (mrad/yr)/(μCi/sec) | \bar{V} (mrad/yr)/(μCi/sec) | Radius (meters) | G (mrad/yr)/(μCi/sec) | \bar{G} (mrad/yr)/(μCi/sec) |
| N | 768 | 768 | 3.231E-04 | 3.124E-04 | 768 | 1.124E-03 | 1.085E-03 | 768 | 2.824E-03 | 2.720E-03 |
| NNE | 1207 | 1207 | 2.031E-04 | 1.964E-04 | 1207 | 5.521E-04 | 5.329E-04 | 1207 | 1.269E-03 | 1.222E-03 |
| NE | 1100 | 1100 | 1.979E-04 | 1.914E-04 | 1100 | 5.468E-04 | 5.279E-04 | 1100 | 1.305E-03 | 1.257E-03 |
| ENE | 1244 | 1244 | 1.536E-04 | 1.485E-04 | 1244 | 3.362E-04 | 3.247E-04 | 1244 | 6.595E-04 | 6.355E-04 |
| E | 1000 | 1000 | 2.367E-04 | 2.288E-04 | 1000 | 7.411E-04 | 7.153E-04 | 1000 | 1.693E-03 | 1.631E-03 |
| ESE | 988 | 988 | 2.177E-04 | 2.105E-04 | 988 | 6.173E-04 | 5.958E-04 | 988 | 1.571E-03 | 1.514E-03 |
| SE | 1000 | 1000 | 2.084E-04 | 2.015E-04 | 1000 | 5.726E-04 | 5.528E-04 | 1000 | 1.533E-03 | 1.477E-03 |
| SSE | 792 | 792 | 2.399E-04 | 2.320E-04 | 792 | 7.020E-04 | 6.777E-04 | 792 | 2.066E-03 | 1.990E-03 |
| S | 841 | 841 | 1.838E-04 | 1.777E-04 | 841 | 5.365E-04 | 5.180E-04 | 841 | 1.480E-03 | 1.426E-03 |
| SSW | 853 | 853 | 1.761E-04 | 1.702E-04 | 853 | 5.143E-04 | 4.966E-04 | 853 | 1.442E-03 | 1.389E-03 |
| SW | 1024 | 1024 | 1.595E-04 | 1.542E-04 | 1024 | 4.548E-04 | 4.392E-04 | 1024 | 1.217E-03 | 1.173E-03 |
| WSW | 1170 | 1170 | 1.518E-04 | 1.468E-04 | 1170 | 3.897E-04 | 3.764E-04 | 1170 | 8.550E-04 | 8.240E-04 |
| W | 1756 | 1756 | 8.725E-05 | 8.434E-05 | 1756 | 2.491E-04 | 2.405E-04 | 1756 | 5.456E-04 | 5.260E-04 |
| WNW | 1219 | 1219 | 1.152E-04 | 1.114E-04 | 1219 | 4.090E-04 | 3.949E-04 | 1219 | 1.225E-03 | 1.180E-03 |
| NW | 756 | 756 | 2.251E-04 | 2.177E-04 | 756 | 6.857E-04 | 6.621E-04 | 756 | 1.873E-03 | 1.804E-03 |
| NNW | 671 | 671 | 2.899E-04 | 2.803E-04 | 671 | 1.043E-03 | 1.007E-03 | 671 | 3.115E-03 | 3.000E-03 |

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Table 4-6 (Page 12 of 15)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Site Boundary for Xe-135

| Downwind Direction | Site Boundary (meters) | Elevated (Stack) Release | | | Mixed Mode (Vent) Release | | | Ground Level Release | | |
|--------------------|---------------------------|--------------------------|--------------------------|----------------------------------|---------------------------|--------------------------|----------------------------------|----------------------|--------------------------|----------------------------------|
| | | Radius (meters) | S (mrad/yr)/(μCi/sec) | \bar{S} (mrad/yr)/(μCi/sec) | Radius (meters) | V (mrad/yr)/(μCi/sec) | \bar{V} (mrad/yr)/(μCi/sec) | Radius (meters) | G (mrad/yr)/(μCi/sec) | \bar{G} (mrad/yr)/(μCi/sec) |
| N | 768 | 768 | 1.977E-04 | 1.913E-04 | 768 | 8.258E-04 | 7.984E-04 | 768 | 2.561E-03 | 2.473E-03 |
| NNE | 1207 | 1207 | 1.320E-04 | 1.277E-04 | 1207 | 4.556E-04 | 4.406E-04 | 1207 | 1.315E-03 | 1.270E-03 |
| NE | 1100 | 1100 | 1.279E-04 | 1.238E-04 | 1100 | 4.558E-04 | 4.407E-04 | 1100 | 1.440E-03 | 1.391E-03 |
| ENE | 1244 | 1244 | 1.040E-04 | 1.007E-04 | 1244 | 2.898E-04 | 2.803E-04 | 1244 | 7.532E-04 | 7.276E-04 |
| E | 1000 | 1000 | 1.502E-04 | 1.454E-04 | 1000 | 5.929E-04 | 5.733E-04 | 1000 | 1.654E-03 | 1.597E-03 |
| ESE | 988 | 988 | 1.380E-04 | 1.335E-04 | 988 | 4.921E-04 | 4.758E-04 | 988 | 1.571E-03 | 1.517E-03 |
| SE | 1000 | 1000 | 1.329E-04 | 1.287E-04 | 1000 | 4.493E-04 | 4.344E-04 | 1000 | 1.617E-03 | 1.562E-03 |
| SSE | 792 | 792 | 1.475E-04 | 1.427E-04 | 792 | 5.356E-04 | 5.179E-04 | 792 | 2.030E-03 | 1.960E-03 |
| S | 841 | 841 | 1.235E-04 | 1.195E-04 | 841 | 4.212E-04 | 4.073E-04 | 841 | 1.649E-03 | 1.593E-03 |
| SSW | 853 | 853 | 1.157E-04 | 1.120E-04 | 853 | 4.047E-04 | 3.914E-04 | 853 | 1.524E-03 | 1.472E-03 |
| SW | 1024 | 1024 | 1.052E-04 | 1.018E-04 | 1024 | 3.800E-04 | 3.675E-04 | 1024 | 1.384E-03 | 1.337E-03 |
| WSW | 1170 | 1170 | 1.031E-04 | 9.974E-05 | 1170 | 3.328E-04 | 3.218E-04 | 1170 | 1.002E-03 | 9.680E-04 |
| W | 1756 | 1756 | 6.772E-05 | 6.553E-05 | 1756 | 2.411E-04 | 2.332E-04 | 1756 | 7.180E-04 | 6.938E-04 |
| WNW | 1219 | 1219 | 7.868E-05 | 7.615E-05 | 1219 | 3.470E-04 | 3.355E-04 | 1219 | 1.459E-03 | 1.409E-03 |
| NW | 756 | 756 | 1.379E-04 | 1.335E-04 | 756 | 5.259E-04 | 5.086E-04 | 756 | 1.834E-03 | 1.771E-03 |
| NNW | 671 | 671 | 1.754E-04 | 1.697E-04 | 671 | 7.662E-04 | 7.408E-04 | 671 | 2.627E-03 | 2.537E-03 |

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Table 4-6 (Page 13 of 15)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Site Boundary for Xe-137

| Downwind Direction | Site Boundary (meters) | Elevated (Stack) Release | | | Mixed Mode (Vent) Release | | | Ground Level Release | | |
|--------------------|---------------------------|--------------------------|--------------------------|-----------|---------------------------|--------------------------|-----------|----------------------|--------------------------|-----------|
| | | Radius (meters) | S (mrad/yr)/(μCi/sec) | \bar{S} | Radius (meters) | V (mrad/yr)/(μCi/sec) | \bar{V} | Radius (meters) | G (mrad/yr)/(μCi/sec) | \bar{G} |
| N | 768 | 768 | 1.107E-04 | 1.071E-04 | 768 | 3.275E-04 | 3.170E-04 | 768 | 6.309E-04 | 6.104E-04 |
| NNE | 1207 | 1207 | 6.023E-05 | 5.830E-05 | 1207 | 1.264E-04 | 1.223E-04 | 1207 | 2.017E-04 | 1.952E-04 |
| NE | 1100 | 1100 | 5.847E-05 | 5.659E-05 | 1100 | 1.267E-04 | 1.226E-04 | 1100 | 2.117E-04 | 2.049E-04 |
| ENE | 1244 | 1244 | 4.063E-05 | 3.933E-05 | 1244 | 7.244E-05 | 7.011E-05 | 1244 | 1.013E-04 | 9.801E-05 |
| E | 1000 | 1000 | 7.256E-05 | 7.024E-05 | 1000 | 1.894E-04 | 1.833E-04 | 1000 | 3.270E-04 | 3.164E-04 |
| ESE | 988 | 988 | 6.769E-05 | 6.552E-05 | 988 | 1.588E-04 | 1.537E-04 | 988 | 2.954E-04 | 2.859E-04 |
| SE | 1000 | 1000 | 6.336E-05 | 6.133E-05 | 1000 | 1.436E-04 | 1.389E-04 | 1000 | 2.687E-04 | 2.600E-04 |
| SSE | 792 | 792 | 7.937E-05 | 7.683E-05 | 792 | 1.916E-04 | 1.855E-04 | 792 | 4.020E-04 | 3.890E-04 |
| S | 841 | 841 | 5.651E-05 | 5.470E-05 | 841 | 1.378E-04 | 1.334E-04 | 841 | 2.539E-04 | 2.457E-04 |
| SSW | 853 | 853 | 5.384E-05 | 5.212E-05 | 853 | 1.293E-04 | 1.251E-04 | 853 | 2.520E-04 | 2.438E-04 |
| SW | 1024 | 1024 | 4.546E-05 | 4.400E-05 | 1024 | 1.042E-04 | 1.009E-04 | 1024 | 1.939E-04 | 1.876E-04 |
| WSW | 1170 | 1170 | 3.874E-05 | 3.750E-05 | 1170 | 7.913E-05 | 7.658E-05 | 1170 | 1.209E-04 | 1.170E-04 |
| W | 1756 | 1756 | 1.752E-05 | 1.696E-05 | 1756 | 3.873E-05 | 3.748E-05 | 1756 | 5.480E-05 | 5.302E-05 |
| WNW | 1219 | 1219 | 2.999E-05 | 2.903E-05 | 1219 | 8.360E-05 | 8.091E-05 | 1219 | 1.722E-04 | 1.666E-04 |
| NW | 756 | 756 | 7.264E-05 | 7.031E-05 | 756 | 1.876E-04 | 1.816E-04 | 756 | 3.834E-04 | 3.710E-04 |
| NNW | 671 | 671 | 9.950E-05 | 9.632E-05 | 671 | 3.095E-04 | 2.995E-04 | 671 | 7.314E-04 | 7.077E-04 |

Dresden Site Meteorological Data 1/78 – 12/87

Table 4-6 (Page 14 of 15)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Site Boundary for Xe-138

| Downwind Direction | Site Boundary (meters) | Elevated (Stack) Release | | | Mixed Mode (Vent) Release | | | Ground Level Release | | |
|--------------------|---------------------------|--------------------------|--------------------------|-----------|---------------------------|--------------------------|-----------|----------------------|--------------------------|-----------|
| | | Radius (meters) | S (mrad/yr)/(μCi/sec) | \bar{S} | Radius (meters) | V (mrad/yr)/(μCi/sec) | \bar{V} | Radius (meters) | G (mrad/yr)/(μCi/sec) | \bar{G} |
| N | 768 | 768 | 8.543E-04 | 8.302E-04 | 768 | 2.494E-03 | 2.422E-03 | 768 | 5.853E-03 | 5.681E-03 |
| NNE | 1207 | 1207 | 5.254E-04 | 5.106E-04 | 1207 | 1.219E-03 | 1.184E-03 | 1207 | 2.614E-03 | 2.537E-03 |
| NE | 1100 | 1100 | 5.164E-04 | 5.019E-04 | 1100 | 1.212E-03 | 1.177E-03 | 1100 | 2.684E-03 | 2.605E-03 |
| ENE | 1244 | 1244 | 3.998E-04 | 3.885E-04 | 1244 | 7.482E-04 | 7.267E-04 | 1244 | 1.362E-03 | 1.322E-03 |
| E | 1000 | 1000 | 6.190E-04 | 6.015E-04 | 1000 | 1.640E-03 | 1.593E-03 | 1000 | 3.507E-03 | 3.404E-03 |
| ESE | 988 | 988 | 5.683E-04 | 5.523E-04 | 988 | 1.367E-03 | 1.327E-03 | 988 | 3.252E-03 | 3.156E-03 |
| SE | 1000 | 1000 | 5.447E-04 | 5.294E-04 | 1000 | 1.273E-03 | 1.237E-03 | 1000 | 3.167E-03 | 3.074E-03 |
| SSE | 792 | 792 | 6.340E-04 | 6.161E-04 | 792 | 1.569E-03 | 1.524E-03 | 792 | 4.277E-03 | 4.151E-03 |
| S | 841 | 841 | 4.874E-04 | 4.737E-04 | 841 | 1.203E-03 | 1.168E-03 | 841 | 3.049E-03 | 2.959E-03 |
| SSW | 853 | 853 | 4.667E-04 | 4.535E-04 | 853 | 1.149E-03 | 1.116E-03 | 853 | 2.974E-03 | 2.886E-03 |
| SW | 1024 | 1024 | 4.199E-04 | 4.081E-04 | 1024 | 1.014E-03 | 9.852E-04 | 1024 | 2.506E-03 | 2.432E-03 |
| WSW | 1170 | 1170 | 3.977E-04 | 3.865E-04 | 1170 | 8.710E-04 | 8.460E-04 | 1170 | 1.758E-03 | 1.706E-03 |
| W | 1756 | 1756 | 2.229E-04 | 2.166E-04 | 1756 | 5.469E-04 | 5.312E-04 | 1756 | 1.115E-03 | 1.082E-03 |
| WNW | 1219 | 1219 | 3.015E-04 | 2.930E-04 | 1219 | 9.027E-04 | 8.767E-04 | 1219 | 2.512E-03 | 2.438E-03 |
| NW | 756 | 756 | 6.013E-04 | 5.844E-04 | 756 | 1.538E-03 | 1.494E-03 | 756 | 3.871E-03 | 3.757E-03 |
| NNW | 671 | 671 | 7.735E-04 | 7.517E-04 | 671 | 2.320E-03 | 2.253E-03 | 671 | 6.461E-03 | 6.271E-03 |

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Table 4-6 (Page 15 of 15)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Site Boundary for Ar-41

| Downwind Direction | Site Boundary (meters) | Elevated (Stack) Release | | | Mixed Mode (Vent) Release | | | Ground Level Release | | |
|--------------------|---------------------------|--------------------------|--------------------------|----------------------------------|---------------------------|--------------------------|----------------------------------|----------------------|--------------------------|----------------------------------|
| | | Radius (meters) | S (mrad/yr)/(μCi/sec) | \bar{S} (mrad/yr)/(μCi/sec) | Radius (meters) | V (mrad/yr)/(μCi/sec) | \bar{V} (mrad/yr)/(μCi/sec) | Radius (meters) | G (mrad/yr)/(μCi/sec) | \bar{G} (mrad/yr)/(μCi/sec) |
| N | 768 | 768 | 1.028E-03 | 9.954E-04 | 768 | 3.199E-03 | 3.097E-03 | 768 | 8.844E-03 | 8.561E-03 |
| NNE | 1207 | 1207 | 6.592E-04 | 6.381E-04 | 1207 | 1.739E-03 | 1.683E-03 | 1207 | 4.481E-03 | 4.337E-03 |
| NE | 1100 | 1100 | 6.501E-04 | 6.293E-04 | 1100 | 1.740E-03 | 1.685E-03 | 1100 | 4.797E-03 | 4.643E-03 |
| ENE | 1244 | 1244 | 5.257E-04 | 5.089E-04 | 1244 | 1.111E-03 | 1.075E-03 | 1244 | 2.509E-03 | 2.429E-03 |
| E | 1000 | 1000 | 7.666E-04 | 7.421E-04 | 1000 | 2.262E-03 | 2.189E-03 | 1000 | 5.647E-03 | 5.466E-03 |
| ESE | 988 | 988 | 7.013E-04 | 6.789E-04 | 988 | 1.884E-03 | 1.824E-03 | 988 | 5.348E-03 | 5.177E-03 |
| SE | 1000 | 1000 | 6.767E-04 | 6.550E-04 | 1000 | 1.740E-03 | 1.684E-03 | 1000 | 5.454E-03 | 5.280E-03 |
| SSE | 792 | 792 | 7.637E-04 | 7.393E-04 | 792 | 2.092E-03 | 2.025E-03 | 792 | 6.943E-03 | 6.721E-03 |
| S | 841 | 841 | 6.416E-04 | 6.210E-04 | 841 | 1.652E-03 | 1.599E-03 | 841 | 5.507E-03 | 5.331E-03 |
| SSW | 853 | 853 | 6.026E-04 | 5.833E-04 | 853 | 1.580E-03 | 1.529E-03 | 853 | 5.130E-03 | 4.966E-03 |
| SW | 1024 | 1024 | 5.432E-04 | 5.258E-04 | 1024 | 1.475E-03 | 1.428E-03 | 1024 | 4.583E-03 | 4.436E-03 |
| WSW | 1170 | 1170 | 5.286E-04 | 5.116E-04 | 1170 | 1.293E-03 | 1.252E-03 | 1170 | 3.310E-03 | 3.204E-03 |
| W | 1756 | 1756 | 3.346E-04 | 3.239E-04 | 1756 | 9.098E-04 | 8.806E-04 | 1756 | 2.358E-03 | 2.283E-03 |
| WNW | 1219 | 1219 | 4.009E-04 | 3.880E-04 | 1219 | 1.327E-03 | 1.285E-03 | 1219 | 4.769E-03 | 4.616E-03 |
| NW | 756 | 756 | 7.304E-04 | 7.070E-04 | 756 | 2.057E-03 | 1.991E-03 | 756 | 6.247E-03 | 6.047E-03 |
| NNW | 671 | 671 | 9.277E-04 | 8.980E-04 | 671 | 2.986E-03 | 2.891E-03 | 671 | 9.202E-03 | 8.907E-03 |

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Table 4-7 (Page 1 of 15)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Restricted Area Boundary for Kr-83m

| Downwind Direction | Site Boundary (meters) | Elevated (Stack) Release | | | Mixed Mode (Vent) Release | | | Ground Level Release | | |
|--------------------|---------------------------|--------------------------|--------------------------|-----------|---------------------------|--------------------------|-----------|----------------------|--------------------------|-----------|
| | | Radius (meters) | S (mrad/yr)/(μCi/sec) | \bar{S} | Radius (meters) | V (mrad/yr)/(μCi/sec) | \bar{V} | Radius (meters) | G (mrad/yr)/(μCi/sec) | \bar{G} |
| N | 466 | 466 | 1.041E-06 | 7.848E-07 | 466 | 1.183E-04 | 8.920E-05 | 466 | 7.750E-04 | 5.844E-04 |
| NNE | 698 | 698 | 1.121E-06 | 8.449E-07 | 698 | 6.129E-05 | 4.621E-05 | 698 | 3.913E-04 | 2.950E-04 |
| NE | 646 | 646 | 1.066E-06 | 8.037E-07 | 646 | 6.013E-05 | 4.534E-05 | 646 | 4.320E-04 | 3.257E-04 |
| ENE | 646 | 646 | 9.380E-07 | 7.072E-07 | 646 | 3.998E-05 | 3.015E-05 | 646 | 2.581E-04 | 1.946E-04 |
| E | 689 | 689 | 1.297E-06 | 9.782E-07 | 689 | 6.576E-05 | 4.958E-05 | 689 | 3.779E-04 | 2.849E-04 |
| ESE | 661 | 661 | 1.460E-06 | 1.101E-06 | 661 | 5.746E-05 | 4.333E-05 | 661 | 3.798E-04 | 2.864E-04 |
| SE | 664 | 664 | 1.647E-06 | 1.242E-06 | 664 | 5.018E-05 | 3.784E-05 | 664 | 3.997E-04 | 3.014E-04 |
| SSE | 744 | 744 | 1.560E-06 | 1.176E-06 | 744 | 3.785E-05 | 2.854E-05 | 744 | 3.091E-04 | 2.330E-04 |
| S | 814 | 814 | 1.112E-06 | 8.384E-07 | 814 | 2.441E-05 | 1.841E-05 | 814 | 2.240E-04 | 1.689E-04 |
| SSW | 789 | 789 | 1.040E-06 | 7.839E-07 | 789 | 2.593E-05 | 1.955E-05 | 789 | 2.244E-04 | 1.692E-04 |
| SW | 414 | 414 | 9.653E-07 | 7.278E-07 | 414 | 6.443E-05 | 4.858E-05 | 414 | 6.919E-04 | 5.217E-04 |
| WSW | 360 | 360 | 6.899E-07 | 5.202E-07 | 360 | 6.746E-05 | 5.087E-05 | 360 | 7.401E-04 | 5.581E-04 |
| W | 454 | 454 | 7.213E-07 | 5.439E-07 | 454 | 7.089E-05 | 5.345E-05 | 454 | 6.422E-04 | 4.842E-04 |
| WNW | 469 | 469 | 6.491E-07 | 4.894E-07 | 469 | 8.073E-05 | 6.087E-05 | 469 | 8.066E-04 | 6.082E-04 |
| NW | 482 | 482 | 7.323E-07 | 5.522E-07 | 482 | 5.751E-05 | 4.336E-05 | 482 | 5.123E-04 | 3.863E-04 |
| NNW | 466 | 466 | 7.395E-07 | 5.576E-07 | 466 | 8.846E-05 | 6.670E-05 | 466 | 6.690E-04 | 5.044E-04 |

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Note: Based on Sargent & Lundy, Nuclear Safeguards and Licensing Division, Calculation, "Appendix I Technical Specification Tables," Revision 2, July 10, 1979.

Table 4-7 (Page 2 of 15)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Restricted Area Boundary for Kr-85m

| Downwind Direction | Site Boundary (meters) | Elevated (Stack) Release | | | Mixed Mode (Vent) Release | | | Ground Level Release | | |
|--------------------|---------------------------|--------------------------|--------------------------|----------------------------------|---------------------------|--------------------------|----------------------------------|----------------------|--------------------------|----------------------------------|
| | | Radius (meters) | S (mrad/yr)/(μCi/sec) | \bar{S} (mrad/yr)/(μCi/sec) | Radius (meters) | V (mrad/yr)/(μCi/sec) | \bar{V} (mrad/yr)/(μCi/sec) | Radius (meters) | G (mrad/yr)/(μCi/sec) | \bar{G} (mrad/yr)/(μCi/sec) |
| N | 466 | 466 | 2.230E-04 | 2.158E-04 | 466 | 1.067E-03 | 1.027E-03 | 466 | 3.594E-03 | 3.437E-03 |
| NNE | 698 | 698 | 1.529E-04 | 1.479E-04 | 698 | 6.163E-04 | 5.932E-04 | 698 | 1.974E-03 | 1.889E-03 |
| NE | 646 | 646 | 1.478E-04 | 1.430E-04 | 646 | 6.061E-04 | 5.834E-04 | 646 | 2.111E-03 | 2.020E-03 |
| ENE | 646 | 646 | 1.333E-04 | 1.290E-04 | 646 | 4.501E-04 | 4.335E-04 | 646 | 1.321E-03 | 1.264E-03 |
| E | 689 | 689 | 1.498E-04 | 1.449E-04 | 689 | 6.595E-04 | 6.348E-04 | 689 | 1.981E-03 | 1.896E-03 |
| ESE | 661 | 661 | 1.424E-04 | 1.378E-04 | 661 | 5.726E-04 | 5.511E-04 | 661 | 1.959E-03 | 1.875E-03 |
| SE | 664 | 664 | 1.391E-04 | 1.346E-04 | 664 | 5.279E-04 | 5.083E-04 | 664 | 2.037E-03 | 1.950E-03 |
| SSE | 744 | 744 | 1.110E-04 | 1.074E-04 | 744 | 4.191E-04 | 4.036E-04 | 744 | 1.626E-03 | 1.556E-03 |
| S | 814 | 814 | 8.973E-05 | 8.679E-05 | 814 | 3.161E-04 | 3.046E-04 | 814 | 1.260E-03 | 1.207E-03 |
| SSW | 789 | 789 | 8.795E-05 | 8.508E-05 | 789 | 3.199E-04 | 3.082E-04 | 789 | 1.239E-03 | 1.187E-03 |
| SW | 414 | 414 | 1.735E-04 | 1.679E-04 | 414 | 7.369E-04 | 7.098E-04 | 414 | 3.258E-03 | 3.115E-03 |
| WSW | 360 | 360 | 2.168E-04 | 2.098E-04 | 360 | 8.360E-04 | 8.055E-04 | 360 | 3.347E-03 | 3.199E-03 |
| W | 454 | 454 | 1.616E-04 | 1.564E-04 | 454 | 7.474E-04 | 7.196E-04 | 454 | 3.018E-03 | 2.886E-03 |
| WNW | 469 | 469 | 1.329E-04 | 1.286E-04 | 469 | 7.339E-04 | 7.061E-04 | 469 | 3.639E-03 | 3.477E-03 |
| NW | 482 | 482 | 1.485E-04 | 1.437E-04 | 482 | 6.336E-04 | 6.101E-04 | 482 | 2.416E-03 | 2.311E-03 |
| NNW | 466 | 466 | 1.744E-04 | 1.688E-04 | 466 | 8.433E-04 | 8.115E-04 | 466 | 3.104E-03 | 2.968E-03 |

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Table 4-7 (Page 3 of 15)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Restricted Area Boundary for Kr-85

| Downwind Direction | Site Boundary (meters) | Elevated (Stack) Release | | | Mixed Mode (Vent) Release | | | Ground Level Release | | |
|--------------------|---------------------------|--------------------------|--------------------------|----------------------------------|---------------------------|--------------------------|----------------------------------|----------------------|--------------------------|----------------------------------|
| | | Radius (meters) | S (mrad/yr)/(μCi/sec) | \bar{S} (mrad/yr)/(μCi/sec) | Radius (meters) | V (mrad/yr)/(μCi/sec) | \bar{V} (mrad/yr)/(μCi/sec) | Radius (meters) | G (mrad/yr)/(μCi/sec) | \bar{G} (mrad/yr)/(μCi/sec) |
| N | 466 | 466 | 3.143E-06 | 3.040E-06 | 466 | 1.231E-05 | 1.190E-05 | 466 | 3.902E-05 | 3.773E-05 |
| NNE | 698 | 698 | 2.122E-06 | 2.052E-06 | 698 | 7.164E-06 | 6.928E-06 | 698 | 2.157E-05 | 2.086E-05 |
| NE | 646 | 646 | 2.066E-06 | 1.998E-06 | 646 | 7.095E-06 | 6.861E-06 | 646 | 2.323E-05 | 2.247E-05 |
| ENE | 646 | 646 | 1.876E-06 | 1.814E-06 | 646 | 5.302E-06 | 5.127E-06 | 646 | 1.455E-05 | 1.407E-05 |
| E | 689 | 689 | 2.087E-06 | 2.018E-06 | 689 | 7.673E-06 | 7.420E-06 | 689 | 2.175E-05 | 2.103E-05 |
| ESE | 661 | 661 | 1.977E-06 | 1.912E-06 | 661 | 6.666E-06 | 6.446E-06 | 661 | 2.151E-05 | 2.080E-05 |
| SE | 664 | 664 | 1.932E-06 | 1.868E-06 | 664 | 6.158E-06 | 5.955E-06 | 664 | 2.246E-05 | 2.172E-05 |
| SSE | 744 | 744 | 1.539E-06 | 1.488E-06 | 744 | 4.926E-06 | 4.763E-06 | 744 | 1.802E-05 | 1.742E-05 |
| S | 814 | 814 | 1.279E-06 | 1.237E-06 | 814 | 3.759E-06 | 3.635E-06 | 814 | 1.416E-05 | 1.369E-05 |
| SSW | 789 | 789 | 1.247E-06 | 1.206E-06 | 789 | 3.782E-06 | 3.657E-06 | 789 | 1.382E-05 | 1.336E-05 |
| SW | 414 | 414 | 2.479E-06 | 2.397E-06 | 414 | 8.698E-06 | 8.411E-06 | 414 | 3.548E-05 | 3.430E-05 |
| WSW | 360 | 360 | 3.110E-06 | 3.008E-06 | 360 | 9.874E-06 | 9.548E-06 | 360 | 3.626E-05 | 3.506E-05 |
| W | 454 | 454 | 2.321E-06 | 2.244E-06 | 454 | 8.737E-06 | 8.449E-06 | 454 | 3.270E-05 | 3.163E-05 |
| WNW | 469 | 469 | 1.894E-06 | 1.832E-06 | 469 | 8.519E-06 | 8.238E-06 | 469 | 3.970E-05 | 3.839E-05 |
| NW | 482 | 482 | 2.110E-06 | 2.041E-06 | 482 | 7.448E-06 | 7.202E-06 | 482 | 2.638E-05 | 2.551E-05 |
| NNW | 466 | 466 | 2.476E-06 | 2.394E-06 | 466 | 9.798E-06 | 9.474E-06 | 466 | 3.357E-05 | 3.246E-05 |

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Table 4-7 (Page 4 of 15)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Restricted Area Boundary for Kr-87

| Downwind Direction | Site Boundary (meters) | Elevated (Stack) Release | | | Mixed Mode (Vent) Release | | | Ground Level Release | | |
|--------------------|---------------------------|--------------------------|--------------------------|----------------------------------|---------------------------|--------------------------|----------------------------------|----------------------|--------------------------|----------------------------------|
| | | Radius (meters) | S (mrad/yr)/(μCi/sec) | \bar{S} (mrad/yr)/(μCi/sec) | Radius (meters) | V (mrad/yr)/(μCi/sec) | \bar{V} (mrad/yr)/(μCi/sec) | Radius (meters) | G (mrad/yr)/(μCi/sec) | \bar{G} (mrad/yr)/(μCi/sec) |
| N | 466 | 466 | 1.137E-03 | 1.105E-03 | 466 | 3.687E-03 | 3.580E-03 | 466 | 1.071E-02 | 1.040E-02 |
| NNE | 698 | 698 | 7.555E-04 | 7.340E-04 | 698 | 2.123E-03 | 2.062E-03 | 698 | 5.856E-03 | 5.686E-03 |
| NE | 646 | 646 | 7.405E-04 | 7.194E-04 | 646 | 2.093E-03 | 2.033E-03 | 646 | 6.143E-03 | 5.965E-03 |
| ENE | 646 | 646 | 6.748E-04 | 6.556E-04 | 646 | 1.576E-03 | 1.530E-03 | 646 | 3.888E-03 | 3.775E-03 |
| E | 689 | 689 | 7.454E-04 | 7.242E-04 | 689 | 2.252E-03 | 2.187E-03 | 689 | 5.844E-03 | 5.674E-03 |
| ESE | 661 | 661 | 7.052E-04 | 6.852E-04 | 661 | 1.965E-03 | 1.908E-03 | 661 | 5.772E-03 | 5.604E-03 |
| SE | 664 | 664 | 6.896E-04 | 6.700E-04 | 664 | 1.837E-03 | 1.784E-03 | 664 | 5.961E-03 | 5.788E-03 |
| SSE | 744 | 744 | 5.478E-04 | 5.322E-04 | 744 | 1.458E-03 | 1.416E-03 | 744 | 4.719E-03 | 4.582E-03 |
| S | 814 | 814 | 4.428E-04 | 4.302E-04 | 814 | 1.107E-03 | 1.075E-03 | 814 | 3.558E-03 | 3.454E-03 |
| SSW | 789 | 789 | 4.371E-04 | 4.247E-04 | 789 | 1.115E-03 | 1.082E-03 | 789 | 3.542E-03 | 3.439E-03 |
| SW | 414 | 414 | 9.088E-04 | 8.830E-04 | 414 | 2.627E-03 | 2.551E-03 | 414 | 9.591E-03 | 9.312E-03 |
| WSW | 360 | 360 | 1.151E-04 | 1.119E-04 | 360 | 3.009E-03 | 2.922E-03 | 360 | 9.936E-03 | 9.647E-03 |
| W | 454 | 454 | 8.516E-04 | 8.275E-04 | 454 | 2.633E-03 | 2.557E-03 | 454 | 8.998E-03 | 8.737E-03 |
| WNW | 469 | 469 | 6.945E-04 | 6.748E-04 | 469 | 2.555E-03 | 2.481E-03 | 469 | 1.066E-02 | 1.035E-02 |
| NW | 482 | 482 | 7.712E-04 | 7.493E-04 | 482 | 2.229E-03 | 2.164E-03 | 482 | 7.109E-03 | 6.902E-03 |
| NNW | 466 | 466 | 8.990E-04 | 8.735E-04 | 466 | 2.932E-03 | 2.847E-03 | 466 | 9.310E-03 | 9.039E-03 |

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Table 4-7 (Page 5 of 15)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Restricted Area Boundary for Kr-88

| Downwind Direction | Site Boundary (meters) | Elevated (Stack) Release | | | Mixed Mode (Vent) Release | | | Ground Level Release | | |
|--------------------|---------------------------|--------------------------|--------------------------|-----------|---------------------------|--------------------------|-----------|----------------------|--------------------------|-----------|
| | | Radius (meters) | S (mrad/yr)/(μCi/sec) | \bar{S} | Radius (meters) | V (mrad/yr)/(μCi/sec) | \bar{V} | Radius (meters) | G (mrad/yr)/(μCi/sec) | \bar{G} |
| N | 466 | 466 | 2.943E-03 | 2.865E-03 | 466 | 8.929E-03 | 8.681E-03 | 466 | 2.587E-02 | 2.511E-02 |
| NNE | 698 | 698 | 1.947E-03 | 1.896E-03 | 698 | 5.194E-03 | 5.050E-03 | 698 | 1.425E-02 | 1.384E-02 |
| NE | 646 | 646 | 1.914E-03 | 1.864E-03 | 646 | 5.149E-03 | 5.007E-03 | 646 | 1.515E-02 | 1.471E-02 |
| ENE | 646 | 646 | 1.751E-03 | 1.705E-03 | 646 | 3.883E-03 | 3.776E-03 | 646 | 9.563E-03 | 9.287E-03 |
| E | 689 | 689 | 1.928E-03 | 1.877E-03 | 689 | 5.527E-03 | 5.374E-03 | 689 | 1.430E-02 | 1.389E-02 |
| ESE | 661 | 661 | 1.821E-03 | 1.772E-03 | 661 | 4.821E-03 | 4.688E-03 | 661 | 1.414E-02 | 1.373E-02 |
| SE | 664 | 664 | 1.783E-03 | 1.735E-03 | 664 | 4.497E-03 | 4.373E-03 | 664 | 1.470E-02 | 1.427E-02 |
| SSE | 744 | 744 | 1.419E-03 | 1.382E-03 | 744 | 3.601E-03 | 3.502E-03 | 744 | 1.172E-02 | 1.138E-02 |
| S | 814 | 814 | 1.180E-03 | 1.148E-03 | 814 | 2.755E-03 | 2.679E-03 | 814 | 9.025E-03 | 8.765E-03 |
| SSW | 789 | 789 | 1.155E-03 | 1.124E-03 | 789 | 2.761E-03 | 2.685E-03 | 789 | 8.882E-03 | 8.627E-03 |
| SW | 414 | 414 | 2.367E-03 | 2.304E-03 | 414 | 6.449E-03 | 6.272E-03 | 414 | 2.333E-02 | 2.265E-02 |
| WSW | 360 | 360 | 2.990E-03 | 2.911E-03 | 360 | 7.340E-03 | 7.139E-03 | 360 | 2.399E-02 | 2.329E-02 |
| W | 454 | 454 | 2.223E-03 | 2.164E-03 | 454 | 6.415E-03 | 6.238E-03 | 454 | 2.169E-02 | 2.106E-02 |
| WNW | 469 | 469 | 1.805E-03 | 1.757E-03 | 469 | 6.215E-03 | 6.043E-03 | 469 | 2.604E-02 | 2.528E-02 |
| NW | 482 | 482 | 2.001E-03 | 1.948E-03 | 482 | 5.457E-03 | 5.307E-03 | 482 | 1.734E-02 | 1.684E-02 |
| NNW | 466 | 466 | 2.333E-03 | 2.271E-03 | 466 | 7.138E-03 | 6.941E-03 | 466 | 2.236E-02 | 2.171E-02 |

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Table 4-7 (Page 6 of 15)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Restricted Area Boundary for Kr-89

| Downwind Direction | Site Boundary (meters) | Elevated (Stack) Release | | | Mixed Mode (Vent) Release | | | Ground Level Release | | |
|--------------------|---------------------------|--------------------------|--------------------------|----------------------------------|---------------------------|--------------------------|----------------------------------|----------------------|--------------------------|----------------------------------|
| | | Radius (meters) | S (mrad/yr)/(μCi/sec) | \bar{S} (mrad/yr)/(μCi/sec) | Radius (meters) | V (mrad/yr)/(μCi/sec) | \bar{V} (mrad/yr)/(μCi/sec) | Radius (meters) | G (mrad/yr)/(μCi/sec) | \bar{G} (mrad/yr)/(μCi/sec) |
| N | 466 | 466 | 1.732E-03 | 1.683E-03 | 466 | 5.035E-03 | 4.891E-03 | 466 | 1.065E-02 | 1.034E-02 |
| NNE | 698 | 698 | 1.031E-03 | 1.002E-03 | 698 | 2.286E-03 | 2.221E-03 | 698 | 4.275E-03 | 4.153E-03 |
| NE | 646 | 646 | 9.950E-04 | 9.670E-04 | 646 | 2.234E-03 | 2.170E-03 | 646 | 4.298E-03 | 4.175E-03 |
| ENE | 646 | 646 | 8.600E-04 | 8.358E-04 | 646 | 1.676E-03 | 1.628E-03 | 646 | 2.825E-03 | 2.744E-03 |
| E | 689 | 689 | 9.705E-04 | 9.431E-04 | 689 | 2.440E-03 | 2.370E-03 | 689 | 4.482E-03 | 4.354E-03 |
| ESE | 661 | 661 | 9.455E-04 | 9.188E-04 | 661 | 2.181E-03 | 2.119E-03 | 661 | 4.358E-03 | 4.232E-03 |
| SE | 664 | 664 | 9.066E-04 | 8.810E-04 | 664 | 2.023E-03 | 1.966E-03 | 664 | 4.112E-03 | 3.994E-03 |
| SSE | 744 | 744 | 6.762E-04 | 6.571E-04 | 744 | 1.429E-03 | 1.388E-03 | 744 | 2.760E-03 | 2.680E-03 |
| S | 814 | 814 | 4.553E-04 | 4.425E-04 | 814 | 9.592E-04 | 9.318E-04 | 814 | 1.596E-03 | 1.550E-03 |
| SSW | 789 | 789 | 4.664E-04 | 4.533E-04 | 789 | 9.763E-04 | 9.484E-04 | 789 | 1.761E-03 | 1.710E-03 |
| SW | 414 | 414 | 1.343E-03 | 1.305E-03 | 414 | 3.343E-03 | 3.248E-03 | 414 | 8.556E-03 | 8.310E-03 |
| WSW | 360 | 360 | 1.768E-03 | 1.718E-03 | 360 | 4.104E-03 | 3.987E-03 | 360 | 9.909E-03 | 9.624E-03 |
| W | 454 | 454 | 1.187E-03 | 1.153E-03 | 454 | 3.343E-03 | 3.247E-03 | 454 | 8.490E-03 | 8.246E-03 |
| WNW | 469 | 469 | 9.873E-04 | 9.595E-04 | 469 | 3.183E-03 | 3.092E-03 | 469 | 9.119E-03 | 8.857E-03 |
| NW | 482 | 482 | 1.096E-03 | 1.065E-03 | 482 | 2.722E-03 | 2.644E-03 | 482 | 6.040E-03 | 5.867E-03 |
| NNW | 466 | 466 | 1.313E-03 | 1.276E-03 | 466 | 3.815E-03 | 3.706E-03 | 466 | 9.388E-03 | 9.118E-03 |

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Table 4-7 (Page 7 of 15)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Restricted Area Boundary for Kr-90

| Downwind Direction | Site Boundary (meters) | Elevated (Stack) Release | | | Mixed Mode (Vent) Release | | | Ground Level Release | | |
|--------------------|---------------------------|--------------------------|--------------------------|----------------------------------|---------------------------|--------------------------|----------------------------------|----------------------|--------------------------|----------------------------------|
| | | Radius (meters) | S (mrad/yr)/(μCi/sec) | \bar{S} (mrad/yr)/(μCi/sec) | Radius (meters) | V (mrad/yr)/(μCi/sec) | \bar{V} (mrad/yr)/(μCi/sec) | Radius (meters) | G (mrad/yr)/(μCi/sec) | \bar{G} (mrad/yr)/(μCi/sec) |
| N | 466 | 466 | 5.929E-04 | 5.755E-04 | 466 | 1.271E-03 | 1.233E-03 | 466 | 1.613E-03 | 1.564E-03 |
| NNE | 698 | 698 | 2.234E-04 | 2.169E-04 | 698 | 2.964E-04 | 2.875E-04 | 698 | 3.053E-04 | 2.960E-04 |
| NE | 646 | 646 | 2.150E-04 | 2.087E-04 | 646 | 2.886E-04 | 2.799E-04 | 646 | 2.853E-04 | 2.766E-04 |
| ENE | 646 | 646 | 1.600E-04 | 1.553E-04 | 646 | 2.232E-04 | 2.165E-04 | 646 | 2.234E-04 | 2.166E-04 |
| E | 689 | 689 | 1.909E-04 | 1.853E-04 | 689 | 3.262E-04 | 3.164E-04 | 689 | 3.357E-04 | 3.255E-04 |
| ESE | 661 | 661 | 2.049E-04 | 1.989E-04 | 661 | 3.190E-04 | 3.094E-04 | 661 | 3.449E-04 | 3.344E-04 |
| SE | 664 | 664 | 1.732E-04 | 1.681E-04 | 664 | 2.602E-04 | 2.524E-04 | 664 | 2.762E-04 | 2.678E-04 |
| SSE | 744 | 744 | 1.077E-04 | 1.046E-04 | 744 | 1.358E-04 | 1.317E-04 | 744 | 1.195E-04 | 1.159E-04 |
| S | 814 | 814 | 5.360E-05 | 5.202E-05 | 814 | 6.541E-05 | 6.345E-05 | 814 | 4.998E-05 | 4.846E-05 |
| SSW | 789 | 789 | 5.864E-05 | 5.692E-05 | 789 | 7.078E-05 | 6.866E-05 | 789 | 5.185E-05 | 5.027E-05 |
| SW | 414 | 414 | 4.047E-04 | 3.929E-04 | 414 | 7.044E-04 | 6.833E-04 | 414 | 9.383E-04 | 9.096E-04 |
| WSW | 360 | 360 | 5.613E-04 | 5.449E-04 | 360 | 9.253E-04 | 8.977E-04 | 360 | 1.276E-03 | 1.237E-03 |
| W | 454 | 454 | 3.031E-04 | 2.943E-04 | 454 | 6.126E-04 | 5.942E-04 | 454 | 8.379E-04 | 8.123E-04 |
| WNW | 469 | 469 | 2.652E-04 | 2.574E-04 | 469 | 5.427E-04 | 5.264E-04 | 469 | 7.684E-04 | 7.449E-04 |
| NW | 482 | 482 | 2.739E-04 | 2.659E-04 | 482 | 4.758E-04 | 4.616E-04 | 482 | 6.150E-04 | 5.962E-04 |
| NNW | 466 | 466 | 3.808E-04 | 3.696E-04 | 466 | 8.240E-04 | 7.992E-04 | 466 | 1.215E-03 | 1.178E-03 |

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Table 4-7 (Page 8 of 15)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Restricted Area Boundary for Xe-131m

| Downwind Direction | Site Boundary (meters) | Elevated (Stack) Release | | | Mixed Mode (Vent) Release | | | Ground Level Release | | |
|--------------------|---------------------------|--------------------------|--------------------------|----------------------------------|---------------------------|--------------------------|----------------------------------|----------------------|--------------------------|----------------------------------|
| | | Radius (meters) | S (mrad/yr)/(μCi/sec) | \bar{S} (mrad/yr)/(μCi/sec) | Radius (meters) | V (mrad/yr)/(μCi/sec) | \bar{V} (mrad/yr)/(μCi/sec) | Radius (meters) | G (mrad/yr)/(μCi/sec) | \bar{G} (mrad/yr)/(μCi/sec) |
| N | 466 | 466 | 5.556E-06 | 5.204E-06 | 466 | 1.153E-04 | 9.164E-05 | 466 | 6.984E-04 | 5.422E-04 |
| NNE | 698 | 698 | 4.133E-06 | 3.812E-06 | 698 | 6.169E-05 | 4.926E-05 | 698 | 3.589E-04 | 2.792E-04 |
| NE | 646 | 646 | 3.982E-06 | 3.675E-06 | 646 | 6.105E-05 | 4.875E-05 | 646 | 4.019E-04 | 3.123E-04 |
| ENE | 646 | 646 | 3.576E-06 | 3.303E-06 | 646 | 4.173E-05 | 3.348E-05 | 646 | 2.409E-04 | 1.874E-04 |
| E | 689 | 689 | 4.208E-06 | 3.855E-06 | 689 | 6.680E-05 | 5.332E-05 | 689 | 3.507E-04 | 2.731E-04 |
| ESE | 661 | 661 | 4.174E-06 | 3.795E-06 | 661 | 5.779E-05 | 4.614E-05 | 661 | 3.524E-04 | 2.743E-04 |
| SE | 664 | 664 | 4.252E-06 | 3.839E-06 | 664 | 5.086E-05 | 4.070E-05 | 664 | 3.743E-04 | 2.912E-04 |
| SSE | 744 | 744 | 3.590E-06 | 3.212E-06 | 744 | 3.899E-05 | 3.128E-05 | 744 | 2.939E-04 | 2.288E-04 |
| S | 814 | 814 | 2.813E-06 | 2.534E-06 | 814 | 2.622E-05 | 2.120E-05 | 814 | 2.202E-04 | 1.717E-04 |
| SSW | 789 | 789 | 2.708E-06 | 2.445E-06 | 789 | 2.755E-05 | 2.221E-05 | 789 | 2.178E-04 | 1.698E-04 |
| SW | 414 | 414 | 4.445E-06 | 4.141E-06 | 414 | 6.611E-05 | 5.314E-05 | 414 | 6.302E-04 | 4.894E-04 |
| WSW | 360 | 360 | 5.145E-06 | 4.865E-06 | 360 | 7.064E-05 | 5.700E-05 | 360 | 6.654E-04 | 5.162E-04 |
| W | 454 | 454 | 4.007E-06 | 3.758E-06 | 454 | 7.148E-05 | 5.722E-05 | 454 | 5.783E-04 | 4.492E-04 |
| WNW | 469 | 469 | 3.335E-06 | 3.119E-06 | 469 | 7.894E-05 | 6.278E-05 | 469 | 7.362E-04 | 5.710E-04 |
| NW | 482 | 482 | 3.732E-06 | 3.489E-06 | 482 | 5.931E-05 | 4.756E-05 | 482 | 4.685E-04 | 3.638E-04 |
| NNW | 466 | 466 | 4.291E-06 | 4.030E-06 | 466 | 8.721E-05 | 6.951E-05 | 466 | 5.987E-04 | 4.649E-04 |

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Table 4-7 (Page 9 of 15)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Restricted Area Boundary for Xe-133m

| Downwind Direction | Site Boundary (meters) | Elevated (Stack) Release | | | Mixed Mode (Vent) Release | | | Ground Level Release | | |
|--------------------|---------------------------|--------------------------|--------------------------|----------------------------------|---------------------------|--------------------------|----------------------------------|----------------------|--------------------------|----------------------------------|
| | | Radius (meters) | S (mrad/yr)/(μCi/sec) | \bar{S} (mrad/yr)/(μCi/sec) | Radius (meters) | V (mrad/yr)/(μCi/sec) | \bar{V} (mrad/yr)/(μCi/sec) | Radius (meters) | G (mrad/yr)/(μCi/sec) | \bar{G} (mrad/yr)/(μCi/sec) |
| N | 466 | 466 | 3.241E-05 | 3.119E-05 | 466 | 2.440E-04 | 2.155E-04 | 466 | 1.136E-03 | 9.602E-04 |
| NNE | 698 | 698 | 2.256E-05 | 2.164E-05 | 698 | 1.363E-04 | 1.211E-04 | 698 | 5.998E-04 | 5.098E-04 |
| NE | 646 | 646 | 2.179E-05 | 2.091E-05 | 646 | 1.346E-04 | 1.195E-04 | 646 | 6.612E-04 | 5.604E-04 |
| ENE | 646 | 646 | 1.965E-05 | 1.886E-05 | 646 | 9.633E-05 | 8.606E-05 | 646 | 4.028E-04 | 3.424E-04 |
| E | 689 | 689 | 2.227E-05 | 2.133E-05 | 689 | 1.468E-04 | 1.304E-04 | 689 | 5.931E-04 | 5.052E-04 |
| ESE | 661 | 661 | 2.134E-05 | 2.040E-05 | 661 | 1.272E-04 | 1.130E-04 | 661 | 5.922E-04 | 5.039E-04 |
| SE | 664 | 664 | 2.103E-05 | 2.006E-05 | 664 | 1.147E-04 | 1.022E-04 | 664 | 6.244E-04 | 5.306E-04 |
| SSE | 744 | 744 | 1.699E-05 | 1.617E-05 | 744 | 8.986E-05 | 8.027E-05 | 744 | 4.942E-04 | 4.206E-04 |
| S | 814 | 814 | 1.376E-05 | 1.312E-05 | 814 | 6.470E-05 | 5.828E-05 | 814 | 3.771E-04 | 3.221E-04 |
| SSW | 789 | 789 | 1.340E-05 | 1.278E-05 | 789 | 6.644E-05 | 5.969E-05 | 789 | 3.712E-04 | 3.167E-04 |
| SW | 414 | 414 | 2.535E-05 | 2.437E-05 | 414 | 1.552E-04 | 1.389E-04 | 414 | 1.028E-03 | 8.695E-04 |
| WSW | 360 | 360 | 3.122E-05 | 3.010E-05 | 360 | 1.715E-04 | 1.542E-04 | 360 | 1.072E-03 | 9.053E-04 |
| W | 454 | 454 | 2.349E-05 | 2.262E-05 | 454 | 1.617E-04 | 1.441E-04 | 454 | 9.451E-04 | 7.998E-04 |
| WNW | 469 | 469 | 1.934E-05 | 1.860E-05 | 469 | 1.676E-04 | 1.480E-04 | 469 | 1.181E-03 | 9.961E-04 |
| NW | 482 | 482 | 2.161E-05 | 2.079E-05 | 482 | 1.360E-04 | 1.214E-04 | 482 | 7.638E-04 | 6.462E-04 |
| NNW | 466 | 466 | 2.531E-05 | 2.437E-05 | 466 | 1.891E-04 | 1.675E-04 | 466 | 9.753E-04 | 8.249E-04 |

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Table 4-7 (Page 10 of 15)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Restricted Area Boundary for Xe-133

| Downwind Direction | Site Boundary (meters) | Elevated (Stack) Release | | | Mixed Mode (Vent) Release | | | Ground Level Release | | |
|--------------------|---------------------------|--------------------------|--------------------------|-----------|---------------------------|--------------------------|-----------|----------------------|--------------------------|-----------|
| | | Radius (meters) | S (mrad/yr)/(μCi/sec) | \bar{S} | Radius (meters) | V (mrad/yr)/(μCi/sec) | \bar{V} | Radius (meters) | G (mrad/yr)/(μCi/sec) | \bar{G} |
| N | 466 | 466 | 2.838E-05 | 2.749E-05 | 466 | 2.710E-04 | 2.466E-04 | 466 | 1.235E-03 | 1.086E-03 |
| NNE | 698 | 698 | 2.043E-05 | 1.974E-05 | 698 | 1.526E-04 | 1.395E-04 | 698 | 6.600E-04 | 5.834E-04 |
| NE | 646 | 646 | 1.949E-05 | 1.883E-05 | 646 | 1.497E-04 | 1.367E-04 | 646 | 7.232E-04 | 6.376E-04 |
| ENE | 646 | 646 | 1.742E-05 | 1.683E-05 | 646 | 1.075E-04 | 9.865E-05 | 646 | 4.427E-04 | 3.913E-04 |
| E | 689 | 689 | 2.012E-05 | 1.941E-05 | 689 | 1.647E-04 | 1.505E-04 | 689 | 6.559E-04 | 5.810E-04 |
| ESE | 661 | 661 | 1.945E-05 | 1.873E-05 | 661 | 1.424E-04 | 1.302E-04 | 661 | 6.530E-04 | 5.778E-04 |
| SE | 664 | 664 | 1.923E-05 | 1.848E-05 | 664 | 1.285E-04 | 1.178E-04 | 664 | 6.863E-04 | 6.064E-04 |
| SSE | 744 | 744 | 1.569E-05 | 1.505E-05 | 744 | 1.006E-04 | 9.237E-05 | 744 | 5.450E-04 | 4.823E-04 |
| S | 814 | 814 | 1.234E-05 | 1.186E-05 | 814 | 7.264E-05 | 6.710E-05 | 814 | 4.196E-04 | 3.726E-04 |
| SSW | 789 | 789 | 1.201E-05 | 1.154E-05 | 789 | 7.469E-05 | 6.887E-05 | 789 | 4.123E-04 | 3.658E-04 |
| SW | 414 | 414 | 2.175E-05 | 2.105E-05 | 414 | 1.717E-04 | 1.578E-04 | 414 | 1.121E-03 | 9.870E-04 |
| WSW | 360 | 360 | 2.634E-05 | 2.555E-05 | 360 | 1.899E-04 | 1.750E-04 | 360 | 1.163E-03 | 1.021E-03 |
| W | 454 | 454 | 1.994E-05 | 1.931E-05 | 454 | 1.796E-04 | 1.645E-04 | 454 | 1.031E-03 | 9.079E-04 |
| WNW | 469 | 469 | 1.660E-05 | 1.607E-05 | 469 | 1.849E-04 | 1.682E-04 | 469 | 1.278E-03 | 1.121E-03 |
| NW | 482 | 482 | 1.863E-05 | 1.804E-05 | 482 | 1.512E-04 | 1.386E-04 | 482 | 8.321E-04 | 7.323E-04 |
| NNW | 466 | 466 | 2.185E-05 | 2.118E-05 | 466 | 2.096E-04 | 1.912E-04 | 466 | 1.062E-03 | 9.343E-04 |

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Table 4-7 (Page 11 of 15)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Restricted Area Boundary for Xe-135m

| Downwind Direction | Site Boundary (meters) | Elevated (Stack) Release | | | Mixed Mode (Vent) Release | | | Ground Level Release | | |
|--------------------|---------------------------|--------------------------|--------------------------|----------------------------------|---------------------------|--------------------------|----------------------------------|----------------------|--------------------------|----------------------------------|
| | | Radius (meters) | S (mrad/yr)/(μCi/sec) | \bar{S} (mrad/yr)/(μCi/sec) | Radius (meters) | V (mrad/yr)/(μCi/sec) | \bar{V} (mrad/yr)/(μCi/sec) | Radius (meters) | G (mrad/yr)/(μCi/sec) | \bar{G} (mrad/yr)/(μCi/sec) |
| N | 466 | 466 | 5.476E-04 | 5.295E-04 | 466 | 2.124E-03 | 2.049E-03 | 466 | 5.997E-03 | 5.773E-03 |
| NNE | 698 | 698 | 3.634E-04 | 3.514E-04 | 698 | 1.154E-03 | 1.114E-03 | 698 | 3.094E-03 | 2.980E-03 |
| NE | 646 | 646 | 3.525E-04 | 3.408E-04 | 646 | 1.121E-03 | 1.082E-03 | 646 | 3.110E-03 | 2.995E-03 |
| ENE | 646 | 646 | 3.159E-04 | 3.054E-04 | 646 | 8.372E-04 | 8.082E-04 | 646 | 1.987E-03 | 1.914E-03 |
| E | 689 | 689 | 3.536E-04 | 3.419E-04 | 689 | 1.215E-03 | 1.173E-03 | 689 | 3.060E-03 | 2.947E-03 |
| ESE | 661 | 661 | 3.372E-04 | 3.260E-04 | 661 | 1.065E-03 | 1.028E-03 | 661 | 2.999E-03 | 2.888E-03 |
| SE | 664 | 664 | 3.282E-04 | 3.173E-04 | 664 | 1.001E-03 | 9.660E-04 | 664 | 3.007E-03 | 2.896E-03 |
| SSE | 744 | 744 | 2.572E-04 | 2.486E-04 | 744 | 7.657E-04 | 7.391E-04 | 744 | 2.290E-03 | 2.206E-03 |
| S | 814 | 814 | 1.908E-04 | 1.844E-04 | 814 | 5.608E-04 | 5.414E-04 | 814 | 1.566E-03 | 1.509E-03 |
| SSW | 789 | 789 | 1.925E-04 | 1.861E-04 | 789 | 5.709E-04 | 5.512E-04 | 789 | 1.643E-03 | 1.583E-03 |
| SW | 414 | 414 | 4.279E-04 | 4.137E-04 | 414 | 1.445E-03 | 1.395E-03 | 414 | 5.165E-03 | 4.973E-03 |
| WSW | 360 | 360 | 5.484E-04 | 5.302E-04 | 360 | 1.692E-03 | 1.634E-03 | 360 | 5.561E-03 | 5.353E-03 |
| W | 454 | 454 | 3.953E-04 | 3.822E-04 | 454 | 1.478E-03 | 1.426E-03 | 454 | 5.053E-03 | 4.865E-03 |
| WNW | 469 | 469 | 3.274E-04 | 3.166E-04 | 469 | 1.441E-03 | 1.390E-03 | 469 | 5.671E-03 | 5.459E-03 |
| NW | 482 | 482 | 3.651E-04 | 3.530E-04 | 482 | 1.223E-03 | 1.180E-03 | 482 | 3.781E-03 | 3.640E-03 |
| NNW | 466 | 466 | 4.270E-04 | 4.129E-04 | 466 | 1.655E-03 | 1.597E-03 | 466 | 5.333E-03 | 5.134E-03 |

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Table 4-7 (Page 12 of 15)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Restricted Area Boundary for Xe-135

| Downwind Direction | Site Boundary (meters) | Elevated (Stack) Release | | | Mixed Mode (Vent) Release | | | Ground Level Release | | |
|--------------------|---------------------------|--------------------------|--------------------------|-----------|---------------------------|--------------------------|-----------|----------------------|--------------------------|-----------|
| | | Radius (meters) | S (mrad/yr)/(μCi/sec) | \bar{S} | Radius (meters) | V (mrad/yr)/(μCi/sec) | \bar{V} | Radius (meters) | G (mrad/yr)/(μCi/sec) | \bar{G} |
| N | 466 | 466 | 3.150E-04 | 3.049E-04 | 466 | 1.457E-03 | 1.408E-03 | 466 | 4.806E-03 | 4.640E-03 |
| NNE | 698 | 698 | 2.157E-04 | 2.087E-04 | 698 | 8.450E-04 | 8.169E-04 | 698 | 2.654E-03 | 2.563E-03 |
| NE | 646 | 646 | 2.086E-04 | 2.019E-04 | 646 | 8.323E-04 | 8.046E-04 | 646 | 2.845E-03 | 2.747E-03 |
| ENE | 646 | 646 | 1.883E-04 | 1.822E-04 | 646 | 6.195E-04 | 5.990E-04 | 646 | 1.781E-03 | 1.720E-03 |
| E | 689 | 689 | 2.114E-04 | 2.046E-04 | 689 | 9.053E-04 | 8.752E-04 | 689 | 2.671E-03 | 2.580E-03 |
| ESE | 661 | 661 | 2.008E-04 | 1.943E-04 | 661 | 7.856E-04 | 7.595E-04 | 661 | 2.641E-03 | 2.550E-03 |
| SE | 664 | 664 | 1.961E-04 | 1.898E-04 | 664 | 7.244E-04 | 7.004E-04 | 664 | 2.749E-03 | 2.655E-03 |
| SSE | 744 | 744 | 1.565E-04 | 1.515E-04 | 744 | 5.768E-04 | 5.577E-04 | 744 | 2.201E-03 | 2.126E-03 |
| S | 814 | 814 | 1.274E-04 | 1.233E-04 | 814 | 4.371E-04 | 4.227E-04 | 814 | 1.721E-03 | 1.662E-03 |
| SSW | 789 | 789 | 1.246E-04 | 1.206E-04 | 789 | 4.416E-04 | 4.270E-04 | 789 | 1.685E-03 | 1.628E-03 |
| SW | 414 | 414 | 2.453E-04 | 2.375E-04 | 414 | 1.013E-03 | 9.796E-04 | 414 | 4.367E-03 | 4.216E-03 |
| WSW | 360 | 360 | 3.066E-04 | 2.967E-04 | 360 | 1.150E-03 | 1.112E-03 | 360 | 4.470E-03 | 4.315E-03 |
| W | 454 | 454 | 2.288E-04 | 2.214E-04 | 454 | 1.025E-03 | 9.907E-04 | 454 | 4.035E-03 | 3.896E-03 |
| WNW | 469 | 469 | 1.879E-04 | 1.818E-04 | 469 | 1.003E-03 | 9.694E-04 | 469 | 4.873E-03 | 4.704E-03 |
| NW | 482 | 482 | 2.099E-04 | 2.031E-04 | 482 | 8.706E-04 | 8.418E-04 | 482 | 3.242E-03 | 3.130E-03 |
| NNW | 466 | 466 | 2.466E-04 | 2.387E-04 | 466 | 1.154E-03 | 1.115E-03 | 466 | 4.144E-03 | 4.001E-03 |

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Table 4-7 (Page 13 of 15)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Restricted Area Boundary for Xe-137

| Downwind Direction | Site Boundary (meters) | Elevated (Stack) Release | | | Mixed Mode (Vent) Release | | | Ground Level Release | | |
|--------------------|---------------------------|--------------------------|--------------------------|----------------------------------|---------------------------|--------------------------|----------------------------------|----------------------|--------------------------|----------------------------------|
| | | Radius (meters) | S (mrad/yr)/(μCi/sec) | \bar{S} (mrad/yr)/(μCi/sec) | Radius (meters) | V (mrad/yr)/(μCi/sec) | \bar{V} (mrad/yr)/(μCi/sec) | Radius (meters) | G (mrad/yr)/(μCi/sec) | \bar{G} (mrad/yr)/(μCi/sec) |
| N | 466 | 466 | 2.127E-04 | 2.059E-04 | 466 | 7.271E-04 | 7.036E-04 | 466 | 1.667E-03 | 1.613E-03 |
| NNE | 698 | 698 | 1.306E-04 | 1.264E-04 | 698 | 3.407E-04 | 3.298E-04 | 698 | 7.018E-04 | 6.790E-04 |
| NE | 646 | 646 | 1.257E-04 | 1.217E-04 | 646 | 3.320E-04 | 3.212E-04 | 646 | 7.049E-04 | 6.821E-04 |
| ENE | 646 | 646 | 1.091E-04 | 1.056E-04 | 646 | 2.481E-04 | 2.401E-04 | 646 | 4.587E-04 | 4.439E-04 |
| E | 689 | 689 | 1.235E-04 | 1.196E-04 | 689 | 3.634E-04 | 3.517E-04 | 689 | 7.273E-04 | 7.037E-04 |
| ESE | 661 | 661 | 1.199E-04 | 1.161E-04 | 661 | 3.234E-04 | 3.130E-04 | 661 | 7.065E-04 | 6.836E-04 |
| SE | 664 | 664 | 1.152E-04 | 1.116E-04 | 664 | 3.001E-04 | 2.904E-04 | 664 | 6.732E-04 | 6.514E-04 |
| SSE | 744 | 744 | 8.688E-05 | 8.410E-05 | 744 | 2.147E-04 | 2.078E-04 | 744 | 4.630E-04 | 4.480E-04 |
| S | 814 | 814 | 5.937E-05 | 5.747E-05 | 814 | 1.464E-04 | 1.416E-04 | 814 | 2.744E-04 | 2.655E-04 |
| SSW | 789 | 789 | 6.060E-05 | 5.866E-05 | 789 | 1.492E-04 | 1.444E-04 | 789 | 3.031E-04 | 2.933E-04 |
| SW | 414 | 414 | 1.639E-04 | 1.586E-04 | 414 | 4.811E-04 | 4.656E-04 | 414 | 1.355E-03 | 1.311E-03 |
| WSW | 360 | 360 | 2.140E-04 | 2.072E-04 | 360 | 5.836E-04 | 5.648E-04 | 360 | 1.551E-03 | 1.500E-03 |
| W | 454 | 454 | 1.459E-04 | 1.412E-04 | 454 | 4.851E-04 | 4.694E-04 | 454 | 1.350E-03 | 1.306E-03 |
| WNW | 469 | 469 | 1.216E-04 | 1.177E-04 | 469 | 4.653E-04 | 4.503E-04 | 469 | 1.456E-03 | 1.409E-03 |
| NW | 482 | 482 | 1.353E-04 | 1.310E-04 | 482 | 3.948E-04 | 3.821E-04 | 482 | 9.630E-04 | 9.318E-04 |
| NNW | 466 | 466 | 1.616E-04 | 1.564E-04 | 466 | 5.529E-04 | 5.350E-04 | 466 | 1.478E-03 | 1.430E-03 |

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Table 4-7 (Page 14 of 15)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Restricted Area Boundary for Xe-138

| Downwind Direction | Site Boundary (meters) | Elevated (Stack) Release | | | Mixed Mode (Vent) Release | | | Ground Level Release | | |
|--------------------|---------------------------|--------------------------|--------------------------|----------------------------------|---------------------------|--------------------------|----------------------------------|----------------------|--------------------------|----------------------------------|
| | | Radius (meters) | S (mrad/yr)/(μCi/sec) | \bar{S} (mrad/yr)/(μCi/sec) | Radius (meters) | V (mrad/yr)/(μCi/sec) | \bar{V} (mrad/yr)/(μCi/sec) | Radius (meters) | G (mrad/yr)/(μCi/sec) | \bar{G} (mrad/yr)/(μCi/sec) |
| N | 466 | 466 | 1.468E-03 | 1.426E-03 | 466 | 4.715E-03 | 4.578E-03 | 466 | 1.246E-02 | 1.209E-02 |
| NNE | 698 | 698 | 9.601E-04 | 9.331E-04 | 698 | 2.564E-03 | 2.490E-03 | 698 | 6.418E-03 | 6.229E-03 |
| NE | 646 | 646 | 9.374E-04 | 9.110E-04 | 646 | 2.497E-03 | 2.425E-03 | 646 | 6.435E-03 | 6.245E-03 |
| ENE | 646 | 646 | 8.443E-04 | 8.205E-04 | 646 | 1.879E-03 | 1.825E-03 | 646 | 4.133E-03 | 4.011E-03 |
| E | 689 | 689 | 9.378E-04 | 9.114E-04 | 689 | 2.697E-03 | 2.619E-03 | 689 | 6.357E-03 | 6.169E-03 |
| ESE | 661 | 661 | 8.926E-04 | 8.675E-04 | 661 | 2.364E-03 | 2.296E-03 | 661 | 6.229E-03 | 6.045E-03 |
| SE | 664 | 664 | 8.697E-04 | 8.452E-04 | 664 | 2.234E-03 | 2.169E-03 | 664 | 6.239E-03 | 6.055E-03 |
| SSE | 744 | 744 | 6.807E-04 | 6.615E-04 | 744 | 1.712E-03 | 1.663E-03 | 744 | 4.744E-03 | 4.604E-03 |
| S | 814 | 814 | 5.066E-04 | 4.923E-04 | 814 | 1.258E-03 | 1.222E-03 | 814 | 3.226E-03 | 3.132E-03 |
| SSW | 789 | 789 | 5.116E-04 | 4.972E-04 | 789 | 1.277E-03 | 1.240E-03 | 789 | 3.392E-03 | 3.292E-03 |
| SW | 414 | 414 | 1.162E-03 | 1.130E-03 | 414 | 3.252E-03 | 3.158E-03 | 414 | 1.069E-02 | 1.037E-02 |
| WSW | 360 | 360 | 1.499E-03 | 1.456E-03 | 360 | 3.830E-03 | 3.720E-03 | 360 | 1.153E-02 | 1.118E-02 |
| W | 454 | 454 | 1.077E-03 | 1.047E-03 | 454 | 3.311E-03 | 3.215E-03 | 454 | 1.049E-02 | 1.018E-02 |
| WNW | 469 | 469 | 8.887E-04 | 8.637E-04 | 469 | 3.209E-03 | 3.117E-03 | 469 | 1.173E-02 | 1.138E-02 |
| NW | 482 | 482 | 9.879E-04 | 9.601E-04 | 482 | 2.746E-03 | 2.666E-03 | 482 | 7.834E-03 | 7.602E-03 |
| NNW | 466 | 466 | 1.151E-03 | 1.118E-03 | 466 | 3.684E-03 | 3.578E-03 | 466 | 1.109E-02 | 1.076E-02 |

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Table 4-7 (Page 15 of 15)

Maximum Offsite Finite Plume Gamma Dose Factors Based on 1 cm Depth at the Restricted Area Boundary for Ar-41

| Downwind Direction | Site Boundary (meters) | Elevated (Stack) Release | | | Mixed Mode (Vent) Release | | | Ground Level Release | | |
|--------------------|---------------------------|--------------------------|--------------------------|----------------------------------|---------------------------|--------------------------|----------------------------------|----------------------|--------------------------|----------------------------------|
| | | Radius (meters) | S (mrad/yr)/(μCi/sec) | \bar{S} (mrad/yr)/(μCi/sec) | Radius (meters) | V (mrad/yr)/(μCi/sec) | \bar{V} (mrad/yr)/(μCi/sec) | Radius (meters) | G (mrad/yr)/(μCi/sec) | \bar{G} (mrad/yr)/(μCi/sec) |
| N | 466 | 466 | 1.683E-03 | 1.629E-03 | 466 | 5.680E-03 | 5.499E-03 | 466 | 1.694E-02 | 1.640E-02 |
| NNE | 698 | 698 | 1.121E-03 | 1.085E-03 | 698 | 3.281E-03 | 3.176E-03 | 698 | 9.289E-03 | 8.992E-03 |
| NE | 646 | 646 | 1.097E-03 | 1.062E-03 | 646 | 3.240E-03 | 3.136E-03 | 646 | 9.820E-03 | 9.505E-03 |
| ENE | 646 | 646 | 9.994E-04 | 9.674E-04 | 646 | 2.434E-03 | 2.356E-03 | 646 | 6.194E-03 | 5.996E-03 |
| E | 689 | 689 | 1.105E-03 | 1.070E-03 | 689 | 3.488E-03 | 3.377E-03 | 689 | 9.290E-03 | 8.992E-03 |
| ESE | 661 | 661 | 1.046E-03 | 1.012E-03 | 661 | 3.041E-03 | 2.944E-03 | 661 | 9.182E-03 | 8.888E-03 |
| SE | 664 | 664 | 1.022E-03 | 9.898E-04 | 664 | 2.834E-03 | 2.744E-03 | 664 | 9.514E-03 | 9.210E-03 |
| SSE | 744 | 744 | 8.133E-04 | 7.873E-04 | 744 | 2.256E-03 | 2.184E-03 | 744 | 7.558E-03 | 7.316E-03 |
| S | 814 | 814 | 6.637E-04 | 6.424E-04 | 814 | 1.716E-03 | 1.661E-03 | 814 | 5.761E-03 | 5.577E-03 |
| SSW | 789 | 789 | 6.528E-04 | 6.319E-04 | 789 | 1.728E-03 | 1.673E-03 | 789 | 5.704E-03 | 5.521E-03 |
| SW | 414 | 414 | 1.342E-03 | 1.299E-03 | 414 | 4.046E-03 | 3.917E-03 | 414 | 1.524E-02 | 1.475E-02 |
| WSW | 360 | 360 | 1.694E-03 | 1.640E-03 | 360 | 4.622E-03 | 4.474E-03 | 360 | 1.573E-02 | 1.523E-02 |
| W | 454 | 454 | 1.257E-03 | 1.217E-03 | 454 | 4.055E-03 | 3.926E-03 | 454 | 1.422E-02 | 1.377E-02 |
| WNW | 469 | 469 | 1.025E-03 | 9.921E-04 | 469 | 3.940E-03 | 3.814E-03 | 469 | 1.699E-02 | 1.644E-02 |
| NW | 482 | 482 | 1.138E-03 | 1.102E-03 | 482 | 3.437E-03 | 3.327E-03 | 482 | 1.131E-02 | 1.095E-02 |
| NNW | 466 | 466 | 1.329E-03 | 1.287E-03 | 466 | 4.522E-03 | 4.377E-03 | 466 | 1.469E-02 | 1.422E-02 |

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Table 4-8 (Page 1 of 2)
Elevated Level Joint Frequency Distribution Table Summary
300-Foot Elevation Data

Summary Table of Percent by Direction and Class

| Class | N | NNE | NE | ENE | E | ESE | SE | SSE | S | SSW | SW | WSW | W | WNW | NW | NNW | Total |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|---------|
| A | 0.237 | 0.222 | 0.188 | 0.164 | 0.115 | 0.096 | 0.105 | 0.102 | 0.152 | 0.146 | 0.167 | 0.131 | 0.207 | 0.314 | 0.367 | 0.344 | 3.057 |
| B | 0.206 | 0.200 | 0.176 | 0.155 | 0.123 | 0.146 | 0.151 | 0.162 | 0.252 | 0.263 | 0.241 | 0.209 | 0.256 | 0.285 | 0.287 | 0.311 | 3.422 |
| C | 0.289 | 0.246 | 0.260 | 0.236 | 0.225 | 0.194 | 0.240 | 0.268 | 0.338 | 0.441 | 0.350 | 0.362 | 0.515 | 0.475 | 0.469 | 0.462 | 5.368 |
| D | 2.028 | 1.971 | 2.457 | 2.687 | 2.343 | 1.689 | 1.747 | 2.186 | 3.098 | 3.087 | 2.485 | 2.307 | 3.602 | 3.350 | 2.953 | 2.887 | 40.876 |
| E | 1.342 | 1.352 | 1.520 | 1.778 | 1.954 | 1.906 | 1.965 | 2.433 | 3.771 | 3.815 | 2.856 | 1.904 | 2.374 | 2.231 | 2.033 | 1.550 | 34.782 |
| F | 0.494 | 0.476 | 0.397 | 0.244 | 0.257 | 0.463 | 0.777 | 0.745 | 0.816 | 0.938 | 1.089 | 1.076 | 0.793 | 0.587 | 0.644 | 0.450 | 10.246 |
| G | 0.146 | 0.141 | 0.083 | 0.039 | 0.034 | 0.026 | 0.112 | 0.156 | 0.128 | 0.189 | 0.288 | 0.275 | 0.256 | 0.135 | 0.125 | 0.117 | 2.250 |
| Total | 4.742 | 4.607 | 5.080 | 5.304 | 5.050 | 4.520 | 5.098 | 6.052 | 8.554 | 8.879 | 7.475 | 6.263 | 8.002 | 7.376 | 6.878 | 6.119 | 100.000 |

Summary Table of Percent by Direction and Speed

| Speed | N | NNE | NE | ENE | E | ESE | SE | SSE | S | SSW | SW | WSW | W | WNW | NW | NNW | Total |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|---------|
| 0.45 | 0.033 | 0.021 | 0.017 | 0.006 | 0.007 | 0.000 | 0.000 | 0.007 | 0.010 | 0.000 | 0.000 | 0.000 | 0.006 | 0.000 | 0.000 | 0.000 | 0.109 |
| 1.05 | 0.035 | 0.035 | 0.031 | 0.051 | 0.052 | 0.037 | 0.035 | 0.026 | 0.043 | 0.033 | 0.031 | 0.035 | 0.027 | 0.026 | 0.033 | 0.034 | 0.565 |
| 2.05 | 0.240 | 0.209 | 0.213 | 0.244 | 0.265 | 0.223 | 0.216 | 0.220 | 0.221 | 0.171 | 0.235 | 0.249 | 0.223 | 0.240 | 0.229 | 0.210 | 3.608 |
| 3.05 | 0.413 | 0.474 | 0.462 | 0.559 | 0.536 | 0.481 | 0.484 | 0.474 | 0.482 | 0.413 | 0.496 | 0.575 | 0.596 | 0.433 | 0.416 | 0.416 | 7.710 |
| 4.05 | 0.652 | 0.572 | 0.744 | 0.896 | 0.759 | 0.520 | 0.700 | 0.726 | 0.749 | 0.620 | 0.647 | 0.754 | 0.771 | 0.627 | 0.678 | 0.608 | 11.024 |
| 5.05 | 0.638 | 0.640 | 0.751 | 1.062 | 0.785 | 0.563 | 0.778 | 0.797 | 0.771 | 0.794 | 0.729 | 0.724 | 0.840 | 0.692 | 0.847 | 0.739 | 12.151 |
| 6.05 | 0.710 | 0.605 | 0.853 | 0.940 | 0.818 | 0.654 | 0.762 | 0.829 | 0.974 | 1.065 | 0.913 | 0.869 | 1.050 | 0.912 | 1.017 | 0.862 | 13.834 |
| 8.05 | 1.133 | 1.167 | 1.237 | 1.078 | 1.077 | 1.192 | 1.375 | 1.555 | 2.228 | 2.493 | 2.202 | 1.632 | 1.994 | 2.028 | 2.036 | 1.828 | 26.254 |
| 10.05 | 0.559 | 0.552 | 0.554 | 0.386 | 0.508 | 0.506 | 0.515 | 0.850 | 1.612 | 1.793 | 1.286 | 0.848 | 1.253 | 1.396 | 1.082 | 0.924 | 14.623 |
| 13.05 | 0.252 | 0.269 | 0.174 | 0.072 | 0.221 | 0.311 | 0.194 | 0.449 | 1.140 | 1.189 | 0.761 | 0.415 | 0.887 | 0.780 | 0.476 | 0.385 | 7.972 |
| 18.00 | 0.074 | 0.064 | 0.046 | 0.008 | 0.021 | 0.033 | 0.038 | 0.117 | 0.305 | 0.293 | 0.159 | 0.146 | 0.326 | 0.214 | 0.063 | 0.110 | 2.017 |
| 99.00 | 0.004 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 | 0.001 | 0.020 | 0.014 | 0.017 | 0.015 | 0.028 | 0.028 | 0.001 | 0.002 | 0.132 |
| Total | 4.742 | 4.607 | 5.080 | 5.304 | 5.050 | 4.520 | 5.098 | 6.052 | 8.554 | 8.879 | 7.475 | 6.263 | 8.002 | 7.376 | 6.878 | 6.119 | 100.000 |

NOTE: Wind directions in tables are presented in "wind from" and not "wind to" direction.

Table 4-8 (Page 2 of 2)
Elevated Level Joint Frequency Distribution Table Summary
300-Foot Elevation Data

| Summary Table of Percent by Speed and Class | | | | | | | |
|---|-------|-------|-------|-------|-------|-------|-------|
| Class | A | B | C | D | E | F | G |
| Speed | | | | | | | |
| 0.45 | 0.000 | 0.000 | 0.001 | 0.019 | 0.041 | 0.033 | 0.014 |
| 1.05 | 0.005 | 0.008 | 0.026 | 0.188 | 0.203 | 0.107 | 0.027 |
| 2.05 | 0.078 | 0.132 | 0.229 | 1.618 | 0.979 | 0.454 | 0.118 |
| 3.05 | 0.279 | 0.358 | 0.624 | 3.471 | 1.971 | 0.744 | 0.263 |
| 4.05 | 0.502 | 0.572 | 0.830 | 4.500 | 3.159 | 1.166 | 0.295 |
| 5.05 | 0.465 | 0.513 | 0.730 | 4.832 | 4.013 | 1.287 | 0.311 |
| 6.05 | 0.464 | 0.487 | 0.683 | 5.529 | 4.808 | 1.541 | 0.322 |
| 8.05 | 0.687 | 0.768 | 1.127 | 9.927 | 9.863 | 3.289 | 0.593 |
| 10.05 | 0.331 | 0.353 | 0.627 | 5.846 | 5.844 | 1.371 | 0.250 |
| 13.05 | 0.222 | 0.202 | 0.370 | 3.766 | 3.118 | 0.240 | 0.054 |
| 18.00 | 0.024 | 0.030 | 0.115 | 1.115 | 0.720 | 0.013 | 0.001 |
| 99.00 | 0.000 | 0.000 | 0.007 | 0.065 | 0.060 | 0.000 | 0.000 |

Table 4-9 (Page 1 of 4)
Mixed Mode Joint Frequency Distribution Table Summaries
150 Foot Elevation Data

Summary Table of Percent by Direction and Class

| Class | N | NNE | NE | ENE | E | ESE | SE | SSE | S | SSW | SW | WSW | W | WNW | NW | NNW | Total |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| A | 0.609 | 0.428 | 0.323 | 0.250 | 0.369 | 0.452 | 0.457 | 0.508 | 0.703 | 0.775 | 0.741 | 0.777 | 0.698 | 0.809 | 0.949 | 0.972 | 9.821 |
| B | 0.096 | 0.098 | 0.107 | 0.086 | 0.104 | 0.129 | 0.110 | 0.157 | 0.157 | 0.192 | 0.163 | 0.184 | 0.193 | 0.143 | 0.144 | 0.146 | 2.210 |
| C | 0.125 | 0.116 | 0.125 | 0.121 | 0.112 | 0.130 | 0.102 | 0.127 | 0.163 | 0.200 | 0.162 | 0.121 | 0.198 | 0.177 | 0.165 | 0.150 | 2.295 |
| D | 1.083 | 0.984 | 1.267 | 1.306 | 1.295 | 0.929 | 0.875 | 1.120 | 1.395 | 1.253 | 0.982 | 0.897 | 1.489 | 1.173 | 1.335 | 1.316 | 18.699 |
| E | 1.434 | 1.483 | 1.944 | 2.233 | 2.262 | 2.055 | 1.655 | 2.545 | 3.353 | 2.529 | 1.988 | 1.218 | 2.653 | 2.113 | 2.091 | 1.702 | 33.259 |
| F | 0.446 | 0.434 | 0.397 | 0.301 | 0.451 | 0.687 | 0.867 | 0.643 | 1.036 | 1.224 | 1.167 | 0.609 | 0.864 | 0.699 | 0.539 | 0.417 | 10.781 |
| G | 0.200 | 0.123 | 0.094 | 0.084 | 0.069 | 0.105 | 0.366 | 0.230 | 0.187 | 0.269 | 0.557 | 0.633 | 0.318 | 0.207 | 0.208 | 0.167 | 3.816 |
| Total | 3.993 | 3.665 | 4.256 | 4.381 | 4.662 | 4.488 | 4.433 | 5.332 | 6.995 | 6.441 | 5.760 | 4.440 | 6.413 | 5.322 | 5.430 | 4.870 | 80.882 |

Summary Table of Percent by Direction and Speed

| Speed | N | NNE | NE | ENE | E | ESE | SE | SSE | S | SSW | SW | WSW | W | WNW | NW | NNW | Total |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| 0.45 | 0.018 | 0.007 | 0.051 | 0.007 | 0.006 | 0.004 | 0.006 | 0.018 | 0.005 | 0.007 | 0.017 | 0.006 | 0.007 | 0.017 | 0.006 | 0.016 | 0.198 |
| 1.05 | 0.051 | 0.070 | 0.064 | 0.060 | 0.057 | 0.056 | 0.049 | 0.056 | 0.047 | 0.062 | 0.053 | 0.058 | 0.067 | 0.060 | 0.058 | 0.064 | 0.934 |
| 2.05 | 0.361 | 0.306 | 0.365 | 0.421 | 0.392 | 0.371 | 0.340 | 0.315 | 0.397 | 0.349 | 0.380 | 0.388 | 0.432 | 0.347 | 0.339 | 0.324 | 5.828 |
| 3.05 | 0.664 | 0.674 | 0.698 | 0.841 | 0.796 | 0.687 | 0.763 | 0.758 | 0.789 | 0.708 | 0.763 | 0.713 | 0.738 | 0.593 | 0.614 | 0.579 | 11.379 |
| 4.05 | 0.799 | 0.731 | 0.854 | 1.101 | 1.045 | 0.877 | 0.943 | 0.990 | 1.074 | 1.024 | 0.922 | 0.757 | 0.972 | 0.790 | 0.847 | 0.891 | 14.617 |
| 5.05 | 0.803 | 0.649 | 0.799 | 0.958 | 0.993 | 1.025 | 0.984 | 1.109 | 1.238 | 1.225 | 1.126 | 0.862 | 1.146 | 0.910 | 1.086 | 1.024 | 15.937 |
| 6.05 | 0.514 | 0.475 | 0.591 | 0.504 | 0.582 | 0.685 | 0.650 | 0.788 | 1.151 | 1.084 | 0.937 | 0.584 | 0.998 | 0.849 | 0.906 | 0.761 | 12.060 |
| 8.05 | 0.609 | 0.549 | 0.672 | 0.429 | 0.598 | 0.609 | 0.534 | 0.939 | 1.646 | 1.404 | 1.175 | 0.809 | 1.436 | 1.219 | 1.161 | 0.938 | 14.726 |
| 10.05 | 0.157 | 0.180 | 0.151 | 0.057 | 0.175 | 0.161 | 0.151 | 0.328 | 0.565 | 0.518 | 0.345 | 0.232 | 0.556 | 0.481 | 0.382 | 0.246 | 4.685 |
| 13.05 | 0.015 | 0.024 | 0.012 | 0.003 | 0.018 | 0.014 | 0.012 | 0.031 | 0.084 | 0.061 | 0.040 | 0.030 | 0.061 | 0.056 | 0.032 | 0.027 | 0.519 |
| 18.00 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 99.00 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Total | 3.993 | 3.665 | 4.256 | 4.381 | 4.662 | 4.488 | 4.433 | 5.332 | 6.995 | 6.441 | 5.760 | 4.440 | 6.413 | 5.322 | 5.430 | 4.870 | 80.882 |

NOTE: Wind directions in tables are presented in "wind from" and not "wind to" direction.

In order to determine the final mixed mode values, 80.882% of the elevated value (presented in the 150 ft Mixed Mode Table) and 19.118% of the ground level value (presented in the 30 ft Mixed Mode Table) are used to calculate the final values.

Table 4-9 (Page 2 of 4)
Mixed Mode Joint Frequency Distribution Table Summaries

150 Foot Elevation Data

| Summary Table of Percent by Speed and Class | | | | | | | |
|---|-------|-------|-------|-------|-------|-------|-------|
| Class | A | B | C | D | E | F | G |
| Speed | | | | | | | |
| 0.45 | 0.006 | 0.001 | 0.000 | 0.023 | 0.075 | 0.042 | 0.050 |
| 1.05 | 0.029 | 0.008 | 0.016 | 0.170 | 0.315 | 0.227 | 0.168 |
| 2.05 | 0.616 | 0.180 | 0.206 | 1.247 | 1.986 | 0.952 | 0.640 |
| 3.05 | 1.657 | 0.385 | 0.309 | 2.341 | 4.046 | 1.830 | 0.811 |
| 4.05 | 1.968 | 0.404 | 0.379 | 2.832 | 5.796 | 2.433 | 0.806 |
| 5.05 | 1.618 | 0.384 | 0.416 | 3.451 | 6.745 | 2.558 | 0.765 |
| 6.05 | 1.363 | 0.289 | 0.300 | 2.823 | 5.242 | 1.621 | 0.421 |
| 8.05 | 1.866 | 0.405 | 0.480 | 4.055 | 6.729 | 1.038 | 0.153 |
| 10.05 | 0.623 | 0.138 | 0.166 | 1.573 | 2.108 | 0.076 | 0.001 |
| 13.05 | 0.075 | 0.016 | 0.023 | 0.184 | 0.217 | 0.004 | 0.000 |
| 18.00 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 99.00 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Table 4-9 (Page 3 of 4)
Mixed Mode Joint Frequency Distribution Table Summaries

35 Foot Elevation Data

Summary Table of Percent by Direction and Class

| Class | N | NNE | NE | ENE | E | ESE | SE | SSE | S | SSW | SW | WSW | W | WNW | NW | NNW | Total |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| A | 0.090 | 0.090 | 0.064 | 0.038 | 0.051 | 0.064 | 0.066 | 0.093 | 0.205 | 0.246 | 0.208 | 0.171 | 0.187 | 0.243 | 0.224 | 0.180 | 2.219 |
| B | 0.019 | 0.017 | 0.019 | 0.010 | 0.014 | 0.015 | 0.014 | 0.029 | 0.047 | 0.065 | 0.036 | 0.044 | 0.068 | 0.062 | 0.039 | 0.029 | 0.528 |
| C | 0.022 | 0.022 | 0.023 | 0.012 | 0.016 | 0.019 | 0.013 | 0.033 | 0.060 | 0.077 | 0.040 | 0.040 | 0.064 | 0.086 | 0.057 | 0.045 | 0.632 |
| D | 0.286 | 0.274 | 0.251 | 0.181 | 0.274 | 0.191 | 0.176 | 0.339 | 0.577 | 0.455 | 0.308 | 0.309 | 0.573 | 0.513 | 0.416 | 0.394 | 5.517 |
| E | 0.295 | 0.318 | 0.345 | 0.293 | 0.481 | 0.444 | 0.372 | 0.726 | 1.028 | 0.719 | 0.473 | 0.371 | 0.907 | 0.736 | 0.537 | 0.387 | 8.433 |
| F | 0.035 | 0.041 | 0.027 | 0.014 | 0.054 | 0.138 | 0.086 | 0.123 | 0.159 | 0.164 | 0.161 | 0.077 | 0.128 | 0.089 | 0.063 | 0.061 | 1.420 |
| G | 0.005 | 0.002 | 0.005 | 0.001 | 0.009 | 0.055 | 0.016 | 0.013 | 0.033 | 0.054 | 0.079 | 0.022 | 0.017 | 0.016 | 0.023 | 0.018 | 0.369 |
| Total | 0.752 | 0.764 | 0.734 | 0.550 | 0.899 | 0.927 | 0.743 | 1.357 | 2.109 | 1.780 | 1.305 | 1.034 | 1.944 | 1.746 | 1.359 | 1.115 | 19.118 |

Summary Table of Percent by Direction and Speed

| Speed | N | NNE | NE | ENE | E | ESE | SE | SSE | S | SSW | SW | WSW | W | WNW | NW | NNW | Total |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| 0.45 | 0.000 | 0.001 | 0.000 | 0.001 | 0.000 | 0.000 | 0.004 | 0.000 | 0.000 | 0.000 | 0.003 | 0.003 | 0.007 | 0.003 | 0.000 | 0.000 | 0.023 |
| 1.05 | 0.004 | 0.002 | 0.002 | 0.002 | 0.002 | 0.001 | 0.003 | 0.006 | 0.008 | 0.011 | 0.007 | 0.004 | 0.004 | 0.005 | 0.004 | 0.004 | 0.069 |
| 2.05 | 0.053 | 0.064 | 0.047 | 0.037 | 0.057 | 0.076 | 0.037 | 0.060 | 0.078 | 0.098 | 0.081 | 0.040 | 0.064 | 0.057 | 0.069 | 0.068 | 0.985 |
| 3.05 | 0.128 | 0.145 | 0.156 | 0.162 | 0.203 | 0.261 | 0.122 | 0.175 | 0.189 | 0.178 | 0.184 | 0.095 | 0.202 | 0.182 | 0.162 | 0.181 | 2.727 |
| 4.05 | 0.152 | 0.142 | 0.200 | 0.161 | 0.192 | 0.193 | 0.163 | 0.238 | 0.251 | 0.213 | 0.189 | 0.146 | 0.273 | 0.220 | 0.233 | 0.210 | 3.176 |
| 5.05 | 0.107 | 0.098 | 0.117 | 0.096 | 0.122 | 0.117 | 0.112 | 0.176 | 0.220 | 0.179 | 0.157 | 0.130 | 0.229 | 0.216 | 0.199 | 0.151 | 2.425 |
| 6.05 | 0.105 | 0.080 | 0.090 | 0.041 | 0.098 | 0.086 | 0.076 | 0.150 | 0.203 | 0.208 | 0.138 | 0.123 | 0.228 | 0.201 | 0.181 | 0.125 | 2.133 |
| 8.05 | 0.159 | 0.196 | 0.104 | 0.040 | 0.190 | 0.133 | 0.151 | 0.332 | 0.549 | 0.459 | 0.309 | 0.244 | 0.587 | 0.528 | 0.372 | 0.240 | 4.592 |
| 10.05 | 0.037 | 0.034 | 0.016 | 0.010 | 0.031 | 0.049 | 0.062 | 0.166 | 0.422 | 0.336 | 0.167 | 0.141 | 0.226 | 0.247 | 0.109 | 0.117 | 2.170 |
| 13.05 | 0.008 | 0.000 | 0.002 | 0.000 | 0.003 | 0.009 | 0.013 | 0.050 | 0.173 | 0.087 | 0.064 | 0.091 | 0.107 | 0.076 | 0.029 | 0.019 | 0.733 |
| 18.00 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.004 | 0.016 | 0.012 | 0.006 | 0.018 | 0.014 | 0.012 | 0.001 | 0.000 | 0.082 |
| 99.00 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.001 |
| Total | 0.752 | 0.764 | 0.734 | 0.550 | 0.899 | 0.927 | 0.743 | 1.357 | 2.109 | 1.780 | 1.305 | 1.034 | 1.944 | 1.746 | 1.359 | 1.115 | 19.118 |

NOTE: Wind directions in tables are presented in "wind from" and not "wind to" direction.

Table 4-9 (Page 4 of 4)
Mixed Mode Joint Frequency Distribution Table Summaries

35 Foot Elevation Data

| Summary Table of Percent by Speed and Class | | | | | | | |
|---|-------|-------|-------|-------|-------|-------|-------|
| Class | A | B | C | D | E | F | G |
| Speed | | | | | | | |
| 0.45 | 0.000 | 0.000 | 0.000 | 0.007 | 0.007 | 0.003 | 0.005 |
| 1.05 | 0.000 | 0.000 | 0.000 | 0.007 | 0.013 | 0.027 | 0.022 |
| 2.05 | 0.007 | 0.006 | 0.005 | 0.064 | 0.379 | 0.369 | 0.156 |
| 3.05 | 0.198 | 0.045 | 0.047 | 0.474 | 1.240 | 0.573 | 0.150 |
| 4.05 | 0.363 | 0.078 | 0.089 | 0.825 | 1.490 | 0.298 | 0.033 |
| 5.05 | 0.349 | 0.076 | 0.084 | 0.712 | 1.124 | 0.078 | 0.002 |
| 6.05 | 0.305 | 0.067 | 0.079 | 0.693 | 0.956 | 0.033 | 0.000 |
| 8.05 | 0.601 | 0.147 | 0.181 | 1.630 | 1.998 | 0.036 | 0.000 |
| 10.05 | 0.304 | 0.085 | 0.109 | 0.789 | 0.881 | 0.002 | 0.000 |
| 13.05 | 0.090 | 0.022 | 0.033 | 0.271 | 0.318 | 0.000 | 0.000 |
| 18.00 | 0.001 | 0.004 | 0.005 | 0.044 | 0.028 | 0.000 | 0.000 |
| 99.00 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 |

Table 4-10 (Page 1 of 2)

Ground Level Joint Frequency Distribution Table Summary

Dresden JFD 1978-1987 Ground Level (35 ft)

Summary Table of Percent by Direction and Class

| Class | N | NNE | NE | ENE | E | ESE | SE | SSE | S | SSW | SW | WSW | W | WNW | NW | NNW | Total |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|---------|
| A | 0.668 | 0.524 | 0.386 | 0.304 | 0.405 | 0.510 | 0.547 | 0.580 | 0.888 | 1.027 | 0.915 | 0.946 | 0.913 | 1.070 | 1.259 | 1.093 | 12.055 |
| B | 0.129 | 0.119 | 0.126 | 0.094 | 0.122 | 0.140 | 0.121 | 0.187 | 0.216 | 0.255 | 0.168 | 0.237 | 0.249 | 0.224 | 0.195 | 0.152 | 2.733 |
| C | 0.146 | 0.138 | 0.143 | 0.127 | 0.127 | 0.155 | 0.112 | 0.169 | 0.220 | 0.273 | 0.182 | 0.160 | 0.254 | 0.286 | 0.220 | 0.203 | 2.919 |
| D | 1.337 | 1.295 | 1.544 | 1.343 | 1.569 | 1.166 | 1.044 | 1.517 | 1.913 | 1.732 | 1.218 | 1.163 | 2.085 | 1.788 | 1.814 | 1.707 | 24.236 |
| E | 1.744 | 1.823 | 2.399 | 2.168 | 2.907 | 2.736 | 2.170 | 3.654 | 3.985 | 3.034 | 2.273 | 1.533 | 3.470 | 3.018 | 2.679 | 2.131 | 41.723 |
| F | 0.429 | 0.442 | 0.389 | 0.266 | 0.618 | 1.217 | 0.788 | 0.956 | 1.166 | 1.166 | 1.165 | 0.597 | 0.971 | 0.793 | 0.631 | 0.588 | 12.171 |
| G | 0.120 | 0.082 | 0.056 | 0.054 | 0.121 | 0.551 | 0.170 | 0.188 | 0.327 | 0.483 | 0.643 | 0.197 | 0.178 | 0.262 | 0.390 | 0.338 | 4.163 |
| Total | 4.593 | 4.424 | 5.043 | 4.356 | 5.871 | 6.475 | 4.942 | 7.252 | 8.715 | 7.968 | 6.564 | 4.833 | 8.121 | 7.442 | 7.189 | 6.212 | 100.000 |

Summary Table of Percent by Direction and Speed

| Speed | N | NNE | NE | ENE | E | ESE | SE | SSE | S | SSW | SW | WSW | W | WNW | NW | NNW | Total |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|---------|
| 0.45 | 0.078 | 0.056 | 0.077 | 0.053 | 0.029 | 0.091 | 0.058 | 0.014 | 0.052 | 0.020 | 0.070 | 0.034 | 0.049 | 0.049 | 0.058 | 0.050 | 0.838 |
| 1.05 | 0.361 | 0.229 | 0.265 | 0.227 | 0.240 | 0.216 | 0.234 | 0.251 | 0.267 | 0.259 | 0.246 | 0.182 | 0.231 | 0.265 | 0.299 | 0.287 | 4.058 |
| 2.05 | 1.046 | 1.188 | 1.118 | 0.939 | 1.244 | 1.445 | 0.921 | 1.150 | 1.236 | 1.363 | 1.216 | 0.807 | 1.109 | 1.051 | 1.272 | 1.264 | 18.369 |
| 3.05 | 1.096 | 1.186 | 1.370 | 1.484 | 1.764 | 2.167 | 1.228 | 1.594 | 1.597 | 1.470 | 1.477 | 0.932 | 1.624 | 1.476 | 1.383 | 1.496 | 23.345 |
| 4.05 | 0.884 | 0.799 | 1.177 | 0.983 | 1.208 | 1.227 | 1.084 | 1.531 | 1.592 | 1.357 | 1.143 | 0.896 | 1.559 | 1.330 | 1.407 | 1.263 | 19.439 |
| 5.05 | 0.501 | 0.421 | 0.571 | 0.422 | 0.632 | 0.615 | 0.624 | 0.976 | 1.196 | 0.984 | 0.844 | 0.707 | 1.146 | 1.135 | 1.047 | 0.779 | 12.600 |
| 6.05 | 0.335 | 0.237 | 0.301 | 0.160 | 0.393 | 0.379 | 0.365 | 0.704 | 0.926 | 0.962 | 0.625 | 0.541 | 0.979 | 0.838 | 0.815 | 0.504 | 9.064 |
| 8.05 | 0.246 | 0.275 | 0.146 | 0.077 | 0.324 | 0.273 | 0.343 | 0.785 | 1.173 | 1.062 | 0.680 | 0.477 | 1.063 | 0.949 | 0.761 | 0.428 | 9.062 |
| 10.05 | 0.037 | 0.034 | 0.016 | 0.010 | 0.033 | 0.055 | 0.072 | 0.194 | 0.487 | 0.391 | 0.192 | 0.150 | 0.237 | 0.261 | 0.117 | 0.122 | 2.409 |
| 13.05 | 0.008 | 0.000 | 0.002 | 0.000 | 0.003 | 0.009 | 0.013 | 0.050 | 0.173 | 0.087 | 0.064 | 0.091 | 0.107 | 0.076 | 0.029 | 0.019 | 0.732 |
| 18.00 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.003 | 0.016 | 0.012 | 0.006 | 0.017 | 0.014 | 0.012 | 0.001 | 0.000 | 0.082 |
| 99.00 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.001 |
| Total | 4.593 | 4.424 | 5.043 | 4.356 | 5.871 | 6.475 | 4.942 | 7.252 | 8.715 | 7.968 | 6.564 | 4.833 | 8.121 | 7.442 | 7.189 | 6.212 | 100.000 |

NOTE: Wind directions in tables are presented in "wind from" and not "wind to" direction.

Table 4-10 (Page 2 of 2)

Ground Level Joint Frequency Distribution Table Summary

| Summary Table of Percent by Speed and Class | | | | | | | |
|---|-------|-------|-------|-------|-------|-------|-------|
| Class Speed | A | B | C | D | E | F | G |
| 0.45 | 0.012 | 0.003 | 0.003 | 0.073 | 0.274 | 0.260 | 0.212 |
| 1.05 | 0.070 | 0.023 | 0.035 | 0.406 | 1.413 | 1.326 | 0.785 |
| 2.05 | 1.227 | 0.346 | 0.351 | 2.809 | 6.958 | 4.678 | 2.000 |
| 3.05 | 2.762 | 0.608 | 0.567 | 4.668 | 9.964 | 3.797 | 0.981 |
| 4.05 | 2.612 | 0.560 | 0.597 | 5.211 | 8.689 | 1.593 | 0.177 |
| 5.05 | 1.995 | 0.422 | 0.463 | 3.773 | 5.580 | 0.360 | 0.007 |
| 6.05 | 1.488 | 0.321 | 0.371 | 2.954 | 3.827 | 0.103 | 0.001 |
| 8.05 | 1.433 | 0.328 | 0.372 | 3.159 | 3.719 | 0.052 | 0.000 |
| 10.05 | 0.365 | 0.097 | 0.122 | 0.868 | 0.955 | 0.002 | 0.000 |
| 13.05 | 0.090 | 0.022 | 0.033 | 0.271 | 0.317 | 0.000 | 0.000 |
| 18.00 | 0.001 | 0.003 | 0.005 | 0.044 | 0.028 | 0.000 | 0.000 |
| 99.00 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 |

Table 4-11
Station Characteristics for Dresden 1, 2, 3

STATION: Dresden Nuclear Power Station
LOCATION: Morris, Illinois

CHARACTERISTICS OF ELEVATED RELEASE POINT

- | | |
|---|---|
| 1) Release Height = $\frac{U1}{U2/3} \frac{91.44}{94.49} m^a$ | 2) Diameter = $\frac{U1}{U2/3} \frac{1.40}{3.35} m$ |
| 3) Exit Speed = $\frac{U1}{U2/3} \frac{17.9}{16.6} m/s^a$ | 4) Heat Content = 70 Kcal/s ^a |

CHARACTERISTICS OF VENT STACK RELEASE POINT

- 1) Release Height = 48.77 m^a 2) Diameter = 2.74 m
3) Exit Speed = 12.0 m/s^a

CHARACTERISTICS OF GROUND LEVEL RELEASE

- 1) Release Height = 0 m
2) Building Factor (D) = 42.8 m^a

METEOROLOGICAL DATA

A 400 ft Tower is located 800 m WSW of elevated release point

Tower Data Used in Calculations

| Release Point | Wind Speed and Direction | Differential Temperature |
|-----------------|--------------------------|--------------------------|
| <u>Elevated</u> | <u>300 ft</u> | <u>300-35 ft</u> |
| <u>Vent</u> | <u>150 ft</u> | <u>150-35 ft</u> |
| <u>Ground</u> | <u>35 ft</u> | <u>150-35 ft</u> |

^aUsed in calculating the meteorological and dose factors in Tables 4-5, 4-6, and 4-7.

Table 4-12
Dose Factors for Noble Gases

| Nuclide | Beta Air Dose Factor | Beta Skin Dose Factor | Gamma Air Dose Factor | Gamma Total Body Dose Factor |
|---------|---|---|---|---|
| | N_i (mrad/yr per $\mu\text{Ci}/\text{m}^3$) | L_i (mrem/yr per $\mu\text{Ci}/\text{m}^3$) | M_i (mrad/yr per $\mu\text{Ci}/\text{m}^3$) | K_i (mrem/yr per $\mu\text{Ci}/\text{m}^3$) |
| Kr-83m | 2.88E+02 | --- | 1.93E+01 | 7.56E-02 |
| Kr-85m | 1.97E+03 | 1.46E+03 | 1.23E+03 | 1.17E+03 |
| Kr-85 | 1.95E+03 | 1.34E+03 | 1.72E+01 | 1.61E+01 |
| Kr-87 | 1.03E+04 | 9.73E+03 | 6.17E+03 | 5.92E+03 |
| Kr-88 | 2.93E+03 | 2.37E+03 | 1.52E+04 | 1.47E+04 |
| Kr-89 | 1.06E+04 | 1.01E+04 | 1.73E+04 | 1.66E+04 |
| Kr-90 | 7.83E+03 | 7.29E+03 | 1.63E+04 | 1.56E+04 |
| Xe-131m | 1.11E+03 | 4.76E+02 | 1.56E+02 | 9.15E+01 |
| Xe-133m | 1.48E+03 | 9.94E+02 | 3.27E+02 | 2.51E+02 |
| Xe-133 | 1.05E+03 | 3.06E+02 | 3.53E+02 | 2.94E+02 |
| Xe-135m | 7.39E+02 | 7.11E+02 | 3.36E+03 | 3.12E+03 |
| Xe-135 | 2.46E+03 | 1.86E+03 | 1.92E+03 | 1.81E+03 |
| Xe-137 | 1.27E+04 | 1.22E+04 | 1.51E+03 | 1.42E+03 |
| Xe-138 | 4.75E+03 | 4.13E+03 | 9.21E+03 | 8.83E+03 |
| Ar-41 | 3.28E+03 | 2.69E+03 | 9.30E+03 | 8.84E+03 |

Source: Table B-1 of Reference 6.

Table 4-13 (Page 1 of 3)
External Dose Factors for Standing on Contaminated Ground
DFG_{ij} (mrem/hr per pCi/ m²)

| <u>Element</u> | <u>Total Body Dose Factor</u> | <u>Reference</u> | <u>Element</u> | <u>Total Body Dose Factor</u> | <u>Reference</u> |
|----------------|-------------------------------|------------------|----------------|-------------------------------|------------------|
| H-3 | 0.00E+00 | 6 | Be-7 | 5.95E-10 | 99 |
| C-14 | 0.00E+00 | 6 | F-18 | 1.19E-08 | 99 |
| Na-22 | 2.42E-08 | 99 | Na-24 | 2.50E-08 | 6 |
| Mg-27 | 1.14E-08 | 99 | Mg-28 | 1.48E-08 | 99 |
| Al-26 | 2.95E-08 | 99 | Al-28 | 2.00E-08 | 99 |
| P-32 | 0.00E+00 | 6 | Cl-38 | 1.70E-08 | 99 |
| Ar-41 | 1.39E-08 | 99 | K-40 | 2.22E-09 | 99 |
| K-42 | 4.64E-09 | 99 | K-43 | 1.19E-08 | 99 |
| Ca-47 | 1.14E-08 | 99 | Sc-44 | 2.50E-08 | 99 |
| Sc-46m | 1.21E-09 | 99 | Sc-46 | 2.24E-08 | 99 |
| Sc-47 | 1.46E-09 | 99 | Ti-44 | 1.95E-09 | 99 |
| V-48 | 3.21E-08 | 99 | Cr-51 | 2.20E-10 | 6 |
| Mn-52m | 2.79E-08 | 99 | Mn-52 | 3.80E-08 | 99 |
| Mn-54 | 5.80E-09 | 6 | Mn-56 | 1.10E-08 | 6 |
| Fe-52 | 9.12E-09 | 99 | Fe-55 | 0.00E+00 | 6 |
| Fe-59 | 8.00E-09 | 6 | Co-57 | 1.65E-09 | 99 |
| Co-58 | 7.00E-09 | 6 | Co-60 | 1.70E-08 | 6 |
| Ni-63 | 0.00E+00 | 6 | Ni-65 | 3.70E-09 | 6 |
| Cu-64 | 1.50E-09 | 6 | Cu-67 | 1.52E-09 | 99 |
| Cu-68 | 8.60E-09 ¹ | -- | Zn-65 | 4.00E-09 | 6 |
| Zn-69m | 5.06E-09 | 99 | Zn-69 | 0.00E+00 | 6 |
| Ga-66 | 2.70E-08 | 99 | Ga-67 | 1.89E-09 | 99 |
| Ga-68 | 1.24E-08 | 99 | Ga-72 | 3.00E-08 | 99 |
| Ge-77 | 1.34E-08 | 99 | As-72 | 2.23E-08 | 99 |
| As-73 | 1.16E-10 | 99 | As-74 | 9.41E-09 | 99 |
| As-76 | 6.46E-09 | 99 | As-77 | 1.79E-10 | 99 |
| Se-73 | 1.38E-08 | 99 | Se-75 | 4.98E-09 | 99 |
| Br-77 | 3.84E-09 | 99 | Br-80 | 2.01E-09 | 99 |
| Br-82 | 3.00E-08 | 99 | Br-83 | 6.40E-11 | 6 |
| Br-84 | 1.20E-08 | 6 | Br-85 | 0.00E+00 | 6 |
| Kr-79 | 3.07E-09 | 99 | Kr-81 | 1.59E-10 | 99 |
| Kr-83m | 1.42E-11 | 99 | Kr-85m | 2.24E-09 | 99 |
| Kr-85 | 1.35E-10 | 99 | Kr-87 | 1.03E-08 | 99 |
| Kr-88 | 2.07E-08 | 99 | Kr-90 | 1.56E-08 | 99 |
| Rb-84 | 1.07E-08 | 99 | Rb-86 | 6.30E-10 | 6 |
| Rb-87 | 0.00E+00 | 99 | Rb-88 | 3.50E-09 | 6 |
| Rb-89 | 1.50E-08 | 6 | Sr-85 | 6.16E-09 | 99 |
| Sr-87m | 3.92E-09 | 99 | Sr-89 | 5.60E-13 | 6 |
| Sr-90 | 1.84E-11 | 99 | Sr-91 | 7.10E-09 | 6 |
| Sr-92 | 9.00E-09 | 6 | Y-86 | 4.00E-08 | 99 |
| Y-87 | 5.53E-09 | 99 | Y-88 | 2.88E-08 | 99 |
| Y-90 | 2.20E-12 | 6 | Y-91m | 3.80E-09 | 6 |
| Y-91 | 2.40E-11 | 6 | Y-92 | 1.60E-09 | 6 |
| Y-93 | 5.70E-10 | 6 | Zr-95 | 5.00E-09 | 6 |
| Zr-97 | 5.50E-09 | 6 | Nb-94 | 1.84E-08 | 99 |
| Nb-95 | 5.10E-09 | 6 | Nb-97m | 8.57E-09 | 99 |
| Nb-97 | 8.48E-09 | 99 | Mo-99 | 1.90E-09 | 6 |
| Tc-99m | 9.60E-10 | 6 | Tc-101 | 2.70E-09 | 6 |
| Tc-104 | 1.83E-08 ¹ | -- | Ru-97 | 2.99E-09 | 99 |
| Ru-103 | 3.60E-09 | 6 | Ru-105 | 4.50E-09 | 6 |
| Ru/Rh-106 | 5.76E-09 ³ | 6, 99 | Pd-109 | 3.80E-10 | 99 |
| Cd-109 | 1.12E-10 | 99 | In-111 | 5.11E-09 | 99 |
| In-115m | 2.01E-09 | 99 | In-116 | 0.00E+00 ² | -- |
| Sn-113 | 1.15E-09 | 99 | Sn-117m | 1.96E-08 | 99 |
| Sn-119m | 7.05E-11 | 99 | Sb-117 | 0.00E+00 ² | -- |
| Sb-122 | 2.71E-09 ¹ | -- | Sb-124 | 1.16E-08 ¹ | -- |
| Sb-125 | 4.56E-09 | 99 | Sb-126 | 7.13E-10 | 99 |
| Ag-108m | 1.92E-08 | 99 | Ag-108 | 1.14E-09 | 99 |
| Ag-110m | 1.80E-08 | 6 | Ag-111 | 6.75E-10 | 99 |
| Te-121m | 2.65E-09 | 99 | Te-121 | 6.75E-09 | 99 |

Table 4-13 (Page 2 of 3)
External Dose Factors for Standing on Contaminated Ground
DFG_{ij} (mrem/hr per pCi/ m²)

| Element | Total Body Dose Factor | Reference | Element | Total Body Dose Factor | Reference |
|----------------|---------------------------|-----------|-----------|---------------------------|-----------|
| Te-123m | 1.88E-09 | 99 | Te-125m | 3.50E-11 | 6 |
| Te-125 | 0.00E+00 ² | -- | Te-127m | 1.10E-12 | 6 |
| Te-127 | 1.00E-11 | 6 | Te-129m | 7.70E-10 | 6 |
| Te-129 | 7.10E-10 | 6 | Te-131m | 8.40E-09 | 6 |
| Te-131 | 2.20E-09 | 6 | Te-I-132 | 3.40E-09 ⁵ | 6 |
| Te-134 | 1.05E-08 | 99 | I-123 | 2.12E-09 | 99 |
| I-124 | 1.23E-08 | 99 | I-125 | 2.89E-10 | 99 |
| I-130 | 1.40E-08 | 6 | I-131 | 2.80E-09 | 6 |
| I-133 | 3.70E-09 | 6 | I-134 | 1.60E-08 | 6 |
| I-135 | 1.20E-08 | 6 | Xe-127 | 3.44E-09 | 99 |
| Xe-129m | 5.57E-10 | 99 | Xe-131m | 2.13E-10 | 99 |
| Xe-133m | 4.81E-10 | 99 | Xe-133 | 5.91E-10 | 99 |
| Xe-135m | 5.23E-09 | 99 | Xe-135 | 3.36E-09 | 99 |
| Xe-137 | 4.26E-09 | 99 | Xe-138 | 1.30E-08 | 99 |
| Cs-129 | 3.39E-09 | 99 | Cs-132 | 8.40E-09 | 99 |
| Cs-134 | 1.20E-08 | 6 | Cs-136 | 1.50E-08 | 6 |
| Cs-137/Ba-137m | 1.14E-08 ⁴ | 6, 99 | Cs-138 | 2.10E-08 | 6 |
| Cs-139 | 5.15E-09 | 99 | Ba-131 | 5.74E-09 | 99 |
| Ba-133m | 8.10E-10 | 99 | Ba-133 | 4.85E-09 | 99 |
| Ba-135m | 7.26E-10 | 99 | Ba-137m | 7.17E-09 | 99 |
| Ba-137 | 0.00E+00 ² | -- | Ba-139 | 2.40E-09 | 6 |
| Ba-La-140 | 1.71E-08 ⁶ | 6 | Ba-141 | 4.30E-09 | 6 |
| Ba-142 | 7.90E-09 | 6 | La-142 | 1.50E-08 | 6 |
| Ce-139 | 2.04E-09 | 99 | Ce-141 | 5.50E-10 | 6 |
| Ce-143 | 2.20E-09 | 6 | Ce-Pr-144 | 5.20E-10 ⁷ | 6 |
| Pr-142 | 1.84E-09 | 99 | Pr-143 | 0.00E+00 | 6 |
| Nc-147 | 1.00E-09 | 6 | Nc-149 | 5.32E-09 | 99 |
| Pm-145 | 3.38E-10 | 99 | Pm-148m | 2.35E-08 | 99 |
| Pm-148 | 7.22E-09 | 99 | Pm-149 | 5.32E-10 | 99 |
| Sm-153 | 8.95E-10 | 99 | Eu-152 | 1.30E-08 | 99 |
| Eu-154 | 1.41E-08 | 99 | Eu-155 | 8.27E-10 | 99 |
| Gc-153 | 1.46E-09 | 99 | Dy-157 | 4.39E-09 | 99 |
| Er-169 | 6.12E-14 | 99 | Er-171 | 5.11E-09 | 99 |
| Tm-170 | 3.41E-10 | 99 | Yb-169 | 4.12E-09 | 99 |
| Yb-175 | 4.94E-10 | 99 | Lu-177 | 4.60E-10 | 99 |
| Hf-181 | 6.67E-09 | 99 | Ta-182 | 1.42E-08 | 99 |
| Ta-183 | 2.93E-09 ¹ | -- | W-187 | 3.10E-09 | 6 |
| Re-188 | 1.89E-09 | 99 | Os-191 | 9.83E-10 | 99 |
| Ir-194 | 2.31E-09 | 99 | Pt-195m | 9.79E-10 | 99 |
| Pt-197 | 3.57E-10 | 99 | Au-195m | 2.54E-09 | 99 |
| Au-195 | 1.14E-09 | 99 | Au-198 | 5.19E-09 | 99 |
| Au-199 | 1.18E-09 | 99 | Hg-197 | 9.33E-10 | 99 |
| Hg-203 | 2.89E-09 | 99 | Tl-201 | 1.24E-09 | 99 |
| Tl-206 | 0.00E+00 ² | -- | Tl-208 | 3.58E-08 | 99 |
| Pb-203 | 3.88E-09 | 99 | Pb-210 | 3.57E-11 | 99 |
| Pb-212 | 1.91E-09 | 99 | Pb-214 | 3.18E-09 | 99 |
| Bi-206 | 3.74E-08 | 99 | Bi-207 | 1.77E-08 | 99 |
| Bi-214 | 1.71E-08 | 99 | Ra-226 | 8.78E-11 | 99 |
| Th-232 | 8.14E-12 | 99 | U-238 | 7.98E-12 | 99 |
| Np-239 | 9.50E-10 | 6 | Am-241 | 3.48E-10 | 99 |

¹ Valued derived by comparing the percentage and MeV of the nuclide's gammas and then comparing to Cesium-137, as a value was not available in the literature.

² 0.0 due to low yield and short half-life. A value was not available in the literature.

Table 4-13 (Page 3 of 3)
External Dose Factors for Standing on Contaminated Ground
 DFG_{ij} (mrem/hr per pCi/ m²)

- 3 Value is the sum of Ru-106 (1.50E-9) and Rh-106 (4.26E-9). The Rh-106 value is from Reference 99 and the Ru-106 value is from Reference 6.
- 4 Value is the sum of Cs-137 (4.20E-9) and Ba-137m (7.17E-9). The values are from references 6 and 99, respectively.
- 5 Value is the sum of Te-132 (1.70E-9) and I-132 (1.70E-9).
- 6 Value is the sum of Ba-140 (2.10E-9) and La-140 (1.50E-8) from reference 6. In Reference 6, see Table E-6.
- 7 Value is the sum of Ce-144 (3.20E-10) and Pr-144 (2.00E-10) from reference 6.

Notes: Dose assessments for 10CFR20 and 40CFR190 compliance are made for an adult only.

Dose assessments for 10CFR50 Appendix are made using dose factors of Regulatory Guide 1.109 (Reference 6) for all age groups.

Table 4-14
Miscellaneous Dose Assessment Factors: Environmental Parameters

| Parameter and Value | Equation(s) | Basis ^a |
|---|------------------------|--------------------|
| f_f = 1.0 for May through October | 4-20, 4-26 | A |
| = 0.0 for November through April | 4-20, 4-26 | A |
| f_s = 0.5 | 4-22, 4-24 | A |
| f_p = 1.0 for May through October | 4-22, 4-24 | A |
| = 0.0 for November through April | 4-22, 4-24 | A |
| f_g = 0.76 | 4-19 | B |
| f_e = 1.0 | 4-19 | B |
| Q_f = 50 kg/day | 4-22, 4-24 | C |
| r = 1.0 for iodines | 4-20, 4-23, 4-25, 4-26 | B |
| = 0.2 for particulates | 4-20, 4-23, 4-25, 4-26 | B |
| t_b = 262,800 hrs (30 years) | 4-16 | D |
| t_e = 720 hr (30 days) for animal feed (milk or meat pathway) | 4-23, 4-25 | B |
| = 1440 hr (60 days) for produce or leafy vegetables | 4-20, 4-26 | B |
| t_f = 48 hrs (2 days) for milk pathway | 4-22 | B |
| t_h = 0 hr for pasture grass (milk or meat pathway) | 4-23, 4-25 | B |
| = 24 hr for leafy vegetables | 4-26 | B |
| = 1440 hrs (60 days) for produce | 4-20 | B |
| = 2160 hrs (90 days) for stored feed (milk or meat pathway) | 4-23, 4-25 | B |
| t_s = 480 hrs (20 days) for meat pathway | 4-24 | B |
| Y_v = 0.7 kg/m ² for milk and meat pathways | 4-23, 4-25 | B |
| Y_v = 2.0 kg/m ² for produce and leafy vegetables | 4-20, 4-26 | B |
| λ_w = 0.0021 hr ⁻¹ | 4-21, 4-27 | B |

^aBasis key:

- A: Typical for climate of Illinois
- B: Reference 6, Table E-15.
- C: Reference 6, Table E-3.
- D: The parameter t_b is taken as the midpoint of plant operating life (based upon an assumed 60 year plant operating lifetime).

Table 4-15 (Page 1 of 2)
Stable Element Transfer Data

| <u>Element</u> | <u>F_r</u> <u>Meat (d/kg)</u> | <u>F_m(Cow)</u> <u>Milk (d/L)</u> | <u>Reference</u> |
|----------------|--|--|--|
| H | 1.2E-02 | 1.0E-02 | 6 |
| Be | 1.5E-03 | 3.2E-03 | Footnote 1 |
| C | 3.1E-02 | 1.2E-02 | 6 |
| F | 2.9E-03 | 1.4E-02 | Footnote 2 |
| Na | 3.0E-02 | 4.0E-02 | 6 |
| Mg | 1.5E-03 | 3.2E-03 | Footnote 1 |
| Al | 1.5E-02 | 1.3E-03 | Footnote 3 |
| P | 4.6E-02 | 2.5E-02 | 6 |
| Cl | 2.9E-03 | 1.4E-02 | Footnote 2 |
| Ar | NA | NA | NA |
| K | 1.8E-02 | 7.2E-03 | 16 |
| Ca | 1.6E-03 | 1.1E-02 | 16 |
| Sc | 2.4E-03 | 7.5E-06 | Footnote 4 |
| Ti | 3.4E-02 | 5.0E-06 | Footnote 5 |
| V | 2.8E-01 | 1.3E-03 | Footnote 6 |
| Cr | 2.4E-03 | 2.2E-03 | 6 |
| Mn | 8.0E-04 | 2.5E-04 | 6 |
| Fe | 4.0E-02 | 1.2E-03 | 6 |
| Co | 1.3E-02 | 1.0E-03 | 6 |
| Ni | 5.3E-02 | 6.7E-03 | 6 |
| Cu | 8.0E-03 | 1.4E-02 | 6 |
| Zn | 3.0E-02 | 3.9E-02 | 6 |
| Ga | 1.5E-02 | 1.3E-03 | Footnote 3 |
| Ge | 9.1E-04 | 9.9E-05 | Footnote 7 |
| As | 1.7E-02 | 5.0E-04 | Footnote 8 |
| Se | 7.7E-02 | 1.0E-03 | Footnote 9 |
| Br | 2.9E-03 | 2.2E-02 | F _r Footnote 2; F _m from Ref. 16 |
| Kr | NA | NA | NA |
| Rb | 3.1E-02 | 3.0E-02 | 6 |
| Sr | 6.0E-04 | 8.0E-04 | 6 |
| Y | 4.6E-03 | 1.0E-05 | 6 |
| Zr | 3.4E-02 | 5.0E-06 | 6 |
| Nb | 2.8E-01 | 2.5E-03 | 6 |
| Mo | 8.0E-03 | 7.5E-03 | 6 |
| Tc | 4.0E-01 | 2.5E-02 | 6 |
| Ru | 4.0E-01 | 1.0E-06 | 6 |
| Rh | 1.5E-03 | 1.0E-02 | 6 |
| Pd | 5.3E-02 | 6.7E-03 | Footnote 10 |
| Cd | 3.0E-02 | 2.0E-02 | Footnote 11 |
| In | 1.5E-02 | 1.3E-03 | Footnote 3 |
| Sn | 9.1E-04 | 9.9E-05 | Footnote 7 |
| Sb | 5.0E-03 | 2.0E-05 | 98 |
| Ag | 1.7E-02 | 5.0E-02 | 6 |
| Te | 7.7E-02 | 1.0E-03 | 6 |
| I | 2.9E-03 | 6.0E-03 | 6 |
| Xe | NA | NA | NA |
| Cs | 4.0E-03 | 1.2E-02 | 6 |
| Ba | 3.2E-03 | 4.0E-04 | 6 |
| La | 2.0E-04 | 5.0E-06 | 6 |
| Ce | 1.2E-03 | 1.0E-04 | 6 |
| Pr | 4.7E-03 | 5.0E-06 | 6 |
| Nd | 3.3E-03 | 5.0E-06 | 6 |

Table 4-15 (Page 2 of 2)
Stable Element Transfer Data

| <u>Element</u> | <u>F_f</u> <u>Meat (d/kg)</u> | <u>F_m (Cow)</u> <u>Milk (d/L)</u> | <u>Reference</u> |
|----------------|--|---|--|
| Pm | 2.9E-04 | 2.0E-05 | 16 |
| Sm | 2.9E-04 | 2.0E-05 | 16 |
| Eu | 2.9E-04 | 2.0E-05 | 16 |
| Gd | 2.9E-04 | 2.0E-05 | 16 |
| Dy | 2.9E-04 | 2.0E-05 | 16 |
| Er | 2.9E-04 | 2.0E-05 | 16 |
| Tm | 2.9E-04 | 2.0E-05 | 16 |
| Yb | 2.9E-04 | 2.0E-05 | 16 |
| Lu | 2.9E-04 | 2.0E-05 | 16 |
| Hf | 3.4E-02 | 5.0E-06 | Footnote 5 |
| Ta | 2.8E-01 | 1.3E-03 | F _m - Ref.16; F _f -Footnote 6 |
| W | 1.3E-03 | 5.0E-04 | 6 |
| Re | 1.0E-01 | 1.3E-03 | F _m - Ref.16; F _f -Footnote 12 |
| Os | 2.2E-01 | 6.0E-04 | Footnote 13 |
| Ir | 7.3E-03 | 5.5E-03 | Footnote 14 |
| Pt | 5.3E-02 | 6.7E-03 | Footnote 10 |
| Au | 1.3E-02 | 3.2E-02 | Footnote 15 |
| Hg | 3.0E-02 | 9.7E-06 | F _m - Ref.16;F _f -Footnote 11 |
| Tl | 1.5E-02 | 1.3E-03 | F _m - Ref.16; F _f -Footnote 3 |
| Pb | 9.1E-04 | 9.9E-05 | 98 |
| Bi | 1.7E-02 | 5.0E-04 | 98 |
| Ra | 5.5E-04 | 5.9E-04 | 98 |
| Th | 1.6E-06 | 5.0E-06 | 98 |
| U | 1.6E-06 | 1.2E-04 | 98 |
| Np | 2.0E-04 | 5.0E-06 | 6 |
| Am | 1.6E-06 | 2.0E-05 | 98 |

Notes:

1. NA = It is assumed that noble gases are not deposited on the ground.
2. Elements listed are those considered for 10CFR20 assessment and compliance.

Footnotes:

There are numerous F_f and F_m values that were not found in published literature. In these cases, the periodic table was used in conjunction with published values. The periodic table was used based on a general assumption that elements have similar characteristics when in the same column of the periodic table. The values of elements in the same column of the periodic table, excluding atomic numbers 58-71 and 90-103, were averaged then assigned to elements missing values located in the same column of the periodic table. This method was used for all columns where there were missing values except column 3A, where there was no data, hence, the average of column 2B and 4A were used.

1. Values obtained by averaging Reference 6 values of Ca, Sr, Ba, and Ra.
2. F_f value obtained by assigning the Reference 6 value for I. F_m value obtained by averaging I (Ref. 6) and Br (Ref.16).
3. F_f values obtained by averaging Zn (Ref.6) and Pb (Ref. 98); there were no values for elements in the same column; an average is taken between values of columns 2B and 4A on the periodic table. F_m values obtained by using the value for Tl from Reference 16.
4. Values obtained by averaging Reference 6 values of Y and La.
5. Values obtained by assigning the Reference 6 value for Zr.
6. F_f values obtained from Ref. 6 value for Nb. F_m values obtained by averaging values for Nb (Ref.6) and Ta (Ref. 16).
7. Values obtained from the Reference 6 values for Pb.
8. Values obtained from the Reference 6 values for Bi.
9. Values obtained from the Reference 6 values for Te.
10. Values obtained from the Reference 6 values for Ni.
11. F_f values obtained from Ref. 6 values for Zn. F_m values obtained by averaging the Reference 6 values for Zn and Hg.
12. Values obtained by averaging Reference 6 values for Mn, Tc, Nd and Reference 98 value for U.
13. Values obtained by averaging Reference 6 values from Fe and Ru.
14. Values obtained by averaging Reference 6 values from Co and Rh.
15. Values obtained by averaging Reference 6 values from Cu and Ag.

Table 4-16
Atmospheric Stability Classes

| Description | Pasquill Stability Class | ^a σ_{θ} (degrees) | Temperature Change with Height (°C/100 m) |
|------------------------|--------------------------------|---|---|
| Extremely Unstable | A | >22.5 | <-1.9 |
| Moderately Unstable | B | 17.5 to 22.5 | -1.9 to -1.7 |
| Slightly Unstable | C | 12.5 to 17.5 | -1.7 to -1.5 |
| Neutral | D | 7.5 to 12.5 | -1.5 to -0.5 |
| Slightly Stable | E | 3.8 to 7.5 | -0.5 to 1.5 |
| Moderately Stable | F | 2.1 to 3.8 | 1.5 to 4.0 |
| Extremely Stable | G | 0 to 2.1 | >4.0 |

^a σ_{θ} is the standard deviation of horizontal wind direction fluctuation over a period of 15 minutes to 1 hour.

From Regulatory Guide 1.21, Table 4B.

Table 4-17
Vertical Dispersion Parameters

Section 1

Vertical Dispersion Parameters σ_z

σ_z (meters) = aR^b+c with σ_z limited to a maximum of 1000 meters

R = downwind radius (meters)

a, b, and c have the values listed below:

| Stability Class | 100 < R < 1000 | | | R > 1000 | | |
|-----------------|----------------|-------|-------|----------|-------|-------|
| | a | b | c | a | b | c |
| A | * | * | * | 0.00024 | 2.094 | -9.6 |
| B | * | * | * | * | * | * |
| C | 0.113 | 0.911 | 0.0 | * | * | * |
| D | 0.222 | 0.725 | -1.7 | 1.26 | 0.516 | -13.0 |
| E | 0.211 | 0.678 | -1.3 | 6.73 | 0.305 | -34.0 |
| F | 0.086 | 0.74 | -0.35 | 18.05 | 0.18 | -48.6 |
| G | 0.052 | 0.74 | -0.21 | 10.83 | 0.18 | -29.2 |

Basis: Reference 53, except for cases denoted by an asterisk. In these cases, the value of σ_z is obtained by a polynomial approximation to the data from Reference 53 (see Section 2 of this table). The functions given in Reference 50 are not used because they are discontinuous at 1000 meters.

Section 2

Polynomial Approximation for σ_z :

σ_z (meters) = $\exp [a_0 + a_1P + a_2P^2 + a_3P^3]$ with σ_z limited to a maximum of 1000 meters

$P = \log_e [R(\text{meters})]$

a_0, a_1, a_2 and a_3 have the values listed below:

| Stability Class | Radius | Coefficients |
|-----------------|------------------------|------------------|
| A | $100 \leq R \leq 1000$ | $a_0 = -10.50$ |
| | | $a_1 = 6.879$ |
| | | $a_2 = -1.309$ |
| | | $a_3 = 0.0957$ |
| B | $100 \leq R \leq 1000$ | $a_0 = -0.449$ |
| | | $a_1 = 0.218$ |
| | | $a_2 = 0.112$ |
| | | $a_3 = -0.00517$ |
| B | R > 1000 | $a_0 = 319.148$ |
| | | $a_1 = -127.806$ |
| | | $a_2 = 17.093$ |
| | | $a_3 = -0.750$ |
| C | R > 1000 | $a_0 = 5.300$ |
| | | $a_1 = -1.866$ |
| | | $a_2 = 0.3509$ |
| | | $a_3 = -0.01514$ |

Table 4-18

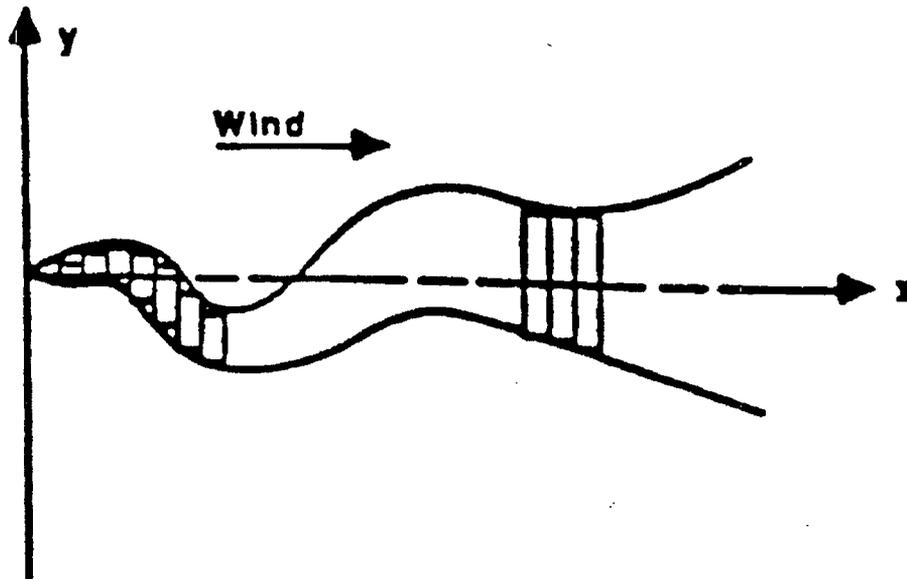
Radionuclide Types Considered For Airborne Effluent Exposure Pathways

| <u>Category</u> | <u>External Radiation</u> | | <u>Internal Radiation</u> | |
|---|---------------------------|---------------|---------------------------|------------------|
| | <u>Plume</u> | <u>Ground</u> | <u>Inhalation</u> | <u>Ingestion</u> |
| Noble Gases | X | | | |
| Tritium (³ H) | | | X | X |
| Carbon-14 (¹⁴ C) ^a | | X | X | |
| Iodine ^b | | X | X | X |
| Particulate ^b | | X | X | X |

^a Dresden is not required to calculate dose due to ¹⁴C.

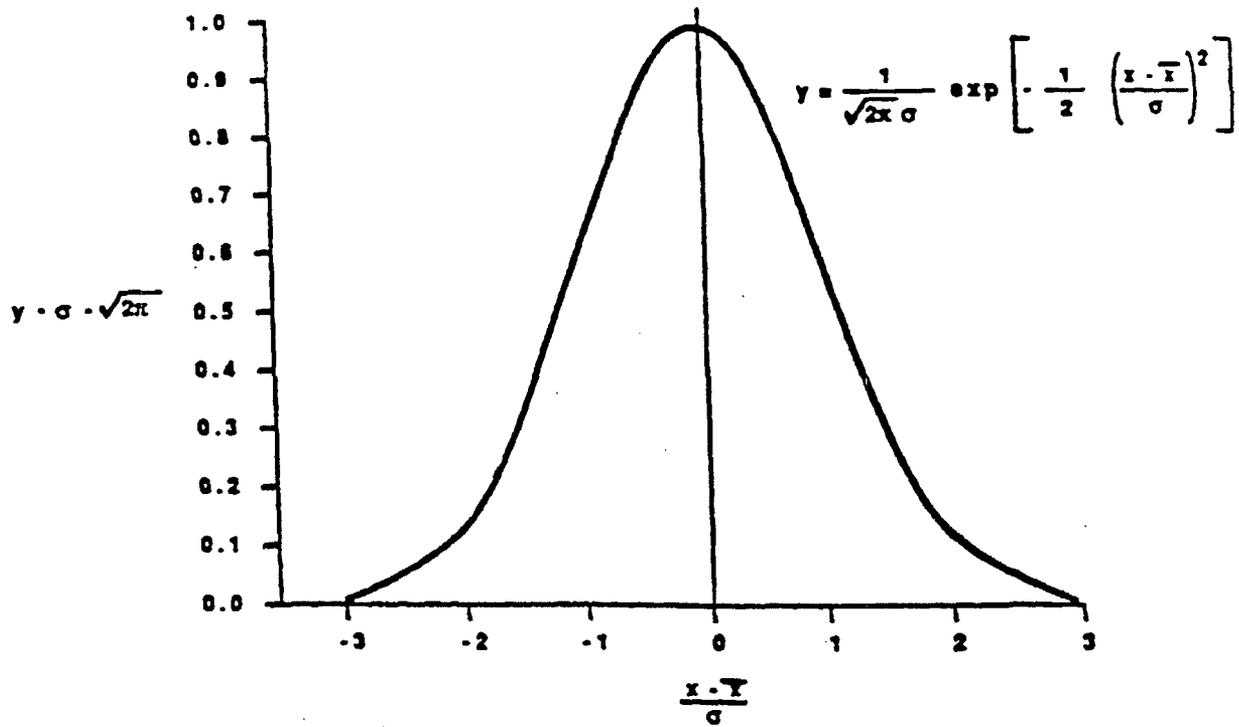
^b Dresden is not required to consider all iodine and particulate radionuclides. For details, see Generic Letter 89-01 and the RECs.

Figure 4-1
Instantaneous View of Plume



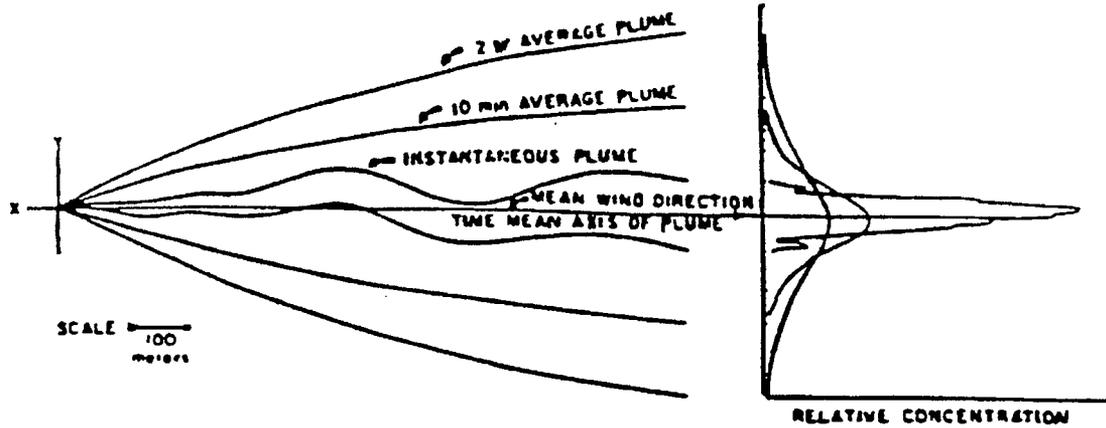
This figure represents a snapshot of a projection of a plume on the horizontal plane. As it moves downwind, the plume meanders about the average wind direction and broadens (adapted from Reference 18).

Figure 4-2
A Gaussian Curve



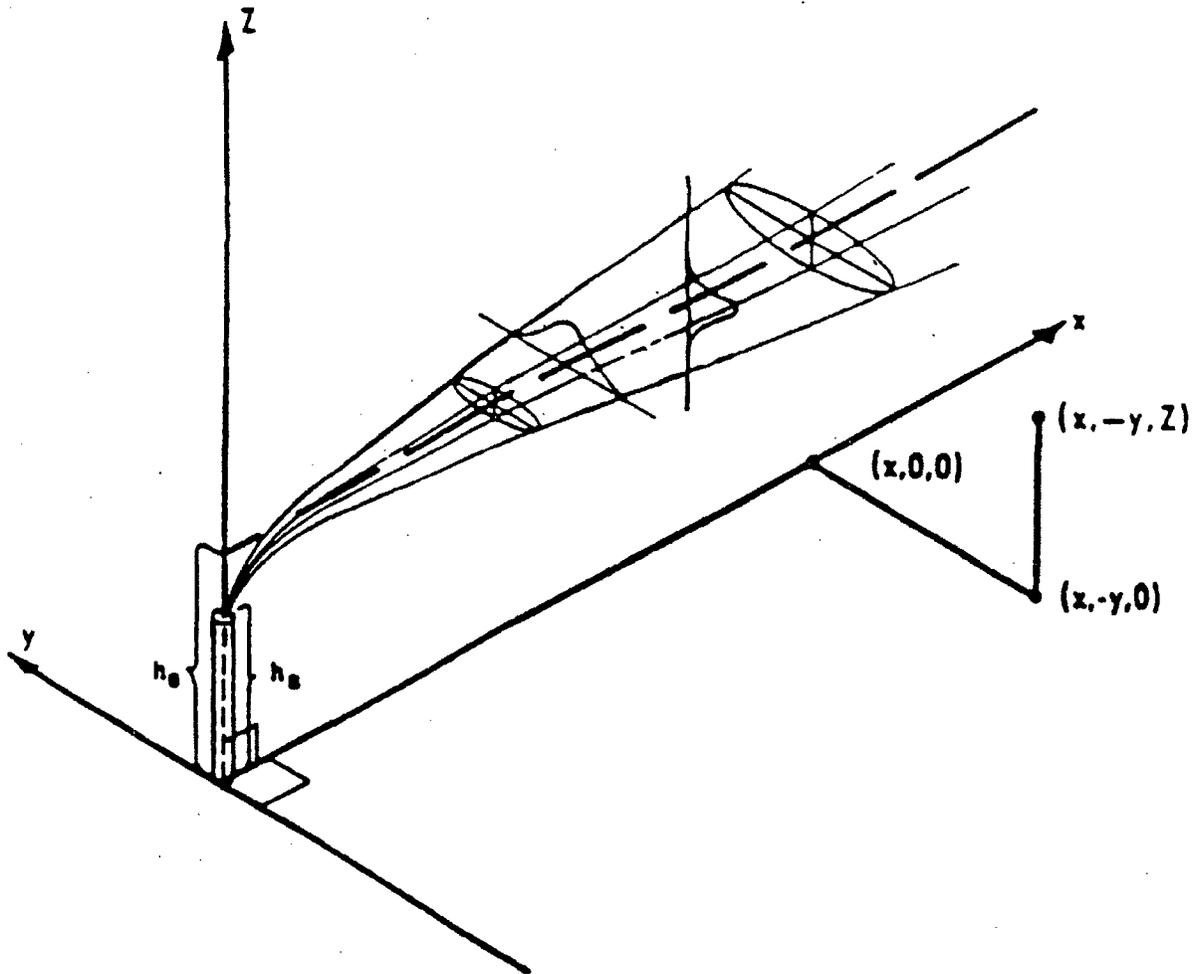
(Adapted from Reference 24 of Chapter 9, Page 61.)

Figure 4-3
Effect of Observation Period on Plume Shape



This sketch represents the approximate outlines of a smoke plume observed instantaneously and averaged over periods of 10 minutes and 2 hours. The diagram on the right shows the corresponding cross plume distribution patterns. The plume width increases as the period of observation increases (from Reference 18).

Figure 4-4
A Gaussian Plume



This sketch illustrates a plume characterized by Equation 4-36. The plume is moving downwind in the x direction. Both the horizontal dispersion parameter σ_z increases as x increases. The reflected component has been omitted in this illustration (adapted from Reference 24).

5.0 Total Dose

Radioactivity contained within tanks, pipes, or other systems and contained radioactive material or waste stored on site can produce radiation at offsite locations. Annual offsite radiation doses near the station due to such sources were judged to be negligible in comparison with applicable limits except for doses due to BWR turbine skyshine and potential doses due to radioactive waste storage facilities (excludes radioactive material storage). Changes or modifications to the power station that may impact the offsite dose through increases to the direct radiation levels need to be evaluated on a case-by-case basis and added to the ODCM when applicable.

5.1 Total Dose Calculation Requirements

5.1.1 Total Effective Dose Equivalent Limits; 10CFR20 and 40CFR190

Dresden is required to determine the total dose to a member of the public due to all uranium fuel cycle sources in order to assess compliance with 40CFR190 as part of demonstrating compliance with 10CFR20.

The total dose for the uranium fuel cycle is the sum of doses due to radioactivity in airborne and liquid effluents and the doses due to direct radiation from contained sources at the nuclear power station and from sources outside the station associated with the uranium fuel cycle. When evaluation of total dose is required for a location near the station, the following contributions are summed:

- Doses due to airborne and liquid effluents from the station.
- Doses due to liquid effluents from nuclear power stations upstream.
- Doses due to ^{16}N skyshine.
- Doses due to any onsite radioactive waste storage facilities, if applicable.
- Doses from nearby facilities that are also part of the uranium fuel cycle (e.g., General Electric Morris Operations)

10CFR20 requires compliance to dose limits expressed as "Total Effective Dose Equivalent" (TEDE). Although annual dose limits in 10CFR20 are now expressed in terms of TEDE, 40CFR190 limits remain stated as organ dose. The NRC continues to require 10CFR50 Appendix I and 40CFR190 doses to be reported in terms of organ dose and not TEDE. Due to the fact that organ dose limits set forth in 40CFR190 are substantially lower than those of 10CFR20 (25 mrem/yr vs. 100 mrem/yr), the NRC has stated that demonstration of compliance with the dose limits in 40CFR190 will be deemed as demonstration of compliance with the dose limits of 10CFR20 for most facilities (Reference 104). In addition to compliance with 40CFR190, it may be necessary for a nuclear power plant to address dose from on-site activity by members of the public.

5.1.2 Independent Spent Fuel Storage Installation (ISFSI)

10CFR72.104 dose limits are the same as those specified by 40CFR190.

Even a fully loaded ISFSI is not expected to become the prominent contributor to the limits in this section. ISFSI dose contribution is in the form of direct radiation as no liquid or gas releases are expected to occur. The 10CFR72.212 report prepared in accordance with ISFSI requirements assumes a certain array of casks exists on the pad. The dose contribution from this array of casks in combination with historical uranium fuel cycle operations prior to ISFSI operations was analyzed to be within the 40CFR190 and 10CFR72.104 limits.

If the dose limits of 40CFR190 or 10CFR72.104 are exceeded, a special report to the NRC as well as an appropriate request for exemption/variance is required to be submitted to the NRC.

5.1.3 Total Dose Calculation Methodology

There are presently two types of contained sources of radioactivity that are of concern in Dresden Station's offsite radiological dose assessments. The first source is that due to gamma rays from nitrogen-16 (^{16}N) carried over to the turbine in boiling water reactor (BWR) steam. The second potential source is that due to gamma rays associated with radioactive material resident in onsite radwaste storage facilities, which is added to the calculation methodology if found to be significant (see Section 5.3).

Gamma radiation from these sources contributes to the whole total body dose (deep dose equivalent). In addition to the total body, skin, and single organ dose assessments previously described, an additional assessment is required. The additional assessment addresses radiation dose due to radioactivity contained within the nuclear power station and its structures.

5.1.4 BWR Skyshine

The most significant dose component to members of the public produced by "contained sources" is nitrogen-16 (^{16}N) within the turbine buildings of BWRs. Although primary side shielding is around the turbine and its piping, ^{16}N gamma rays scattered by air molecules in the overhead air space above the turbine and piping cause a measurable "skyshine" radiation dose in the local power plant environs.

Equation 5-1 is used to evaluate skyshine dose. A complicating factor in the calculation is the practice at some stations of adding hydrogen to reactor coolant to improve coolant chemistry. The addition of hydrogen can increase the dose rate due to skyshine up to a factor of 10 times expected levels depending on injection rates and power levels (Reference 39). Increasing the hydrogen injection rate will increase the dose rates even further (See Reference 102). The skyshine dose determined by Equation 5-1 depends on the following factors:

- The distance of the dose recipient location from the turbine.
- The hours per year that the location is occupied by a dose recipient.
- The total energy [MWe-hr] generated by the station with hydrogen addition.
- The total energy [MWe-hr] generated by the station without hydrogen addition.

5.2 BWR Skyshine Calculation

The contained onsite radioactivity source that results in the most significant offsite radiation levels at Dresden Station is skyshine resulting from ^{16}N decay inside turbines and steam piping.

The ^{16}N that produces the skyshine effect is formulated through neutron activation of the oxygen atoms (oxygen-16, or ^{16}O) in reactor coolant as the coolant passes through the operating reactor core. The ^{16}N travels with the steam produced in the reactor to the steam-driven turbine. While the ^{16}N is in transport, it radioactively decays with a half-life of about 7 seconds and produces 6 to 7 MeV gamma rays. Typically, offsite dose points are shielded from a direct view of components containing ^{16}N , but there can be skyshine radiation at offsite locations due to scattering of gamma rays off the mass of air above the steam lines and turbine.

The offsite dose rate due to skyshine has been found to have the following dependencies:

- The dose rate decreases as distance from the station increases.
- The dose rate increases non-linearly as the power production level increases.
- The dose rate increases when hydrogen is added to the reactor coolant, an action taken to improve reactor coolant chemistry characteristics (see Reference 39).

To calculate offsite dose due to skyshine in a given time period due to skyshine, Dresden Station must track the following parameters:

- The total gross energy E_h produced with hydrogen being added.
- The total gross energy E_o produced without hydrogen being added.

The turbines at the site are sufficiently close to each other that energy generated by the two operating units may be summed.

An initial estimate of skyshine dose is calculated per the following equation:

$$D^{\text{sky}} = (K)(E_o + M_h E_h) \sum_k (OF_k SF_k e^{-0.007R_k}) \quad (5-1)$$

The summation is over all locations k occupied by a hypothetical maximally exposed member of the public characterized by the parameters specified in Table 5-1. The parameters in Equation 5-1 are defined as follows:

| | | |
|------------------|--|---------------------|
| D^{sky} | Dose Due to ^{16}N Skyshine - Gamma External direct gamma dose (deep dose equivalent) due to ^{16}N skyshine for the time period of interest. | [mrem] |
| K | Empirical Constant - A constant determined by fitting data measured at the Dresden station. See Table 5-1. | [mrem/(MWe-hr)] |
| E_o | Electrical Energy Generated Without Hydrogen Addition - Total gross electrical energy generated without hydrogen addition in the time period of interest. | [MWe-hr] |
| E_h | Electrical Energy Generated with Hydrogen Addition - Total gross electrical energy generated with hydrogen addition in the period of interest. | [MWe-hr] |
| M_h | Multiplication Factor for Hydrogen Addition - Factor applied to offsite dose rate when skyshine is present. Hydrogen addition increases main steam line radiation levels typically up to a factor of approximately 5 (see Page 8-1 of Reference 39). M_h is station specific and is given in Table 5-1, dimensionless. | |
| OF_k | Occupancy Factor - The fraction of time that the dose recipient spends at location k during the period of interest. See Table 5-1, dimensionless. | |
| SF_k | Shielding Factor - A dimensionless factor that accounts for shielding due to occupancy of structures, where: $SF_k = 0.7$ if there is a structure at location k; 1.0 otherwise. See Table 5-1. | |
| 0.007 | Empirical Constant - A constant determined by fitting data measured at the Dresden station (see Reference 45). | [m^{-1}] |
| R_k | Distance - Distance from the turbine to location k. See Table 5-1. | [m] |

5.3 Onsite Radwaste and Radioactive Material Storage Facilities

Low-level radwaste may be stored at Dresden in the following types of storage facilities:

- Process Waste Storage Facilities
 - Interim Radwaste Storage Facility (IRSF) structure
 - Concrete vaults containing radwaste liners (aka, 48-pack)
- DAW Storage Facilities
 - Dry Active Waste (DAW) facilities (may include Butler buildings / warehouses)
 - Seavans or other temporary warehouses
- Replaced Steam Dryer Storage Facilities
- Independent spent fuel storage installation (ISFSI) Facilities

The "48-Pack" is a shielded concrete vault, which is designed to hold three tiers of radwaste liners in a four by four array. The outer shell of the "48-Pack" is a three-foot thick concrete wall and a two and one-half foot thick concrete cover slab. The vault is placed on a poured concrete slab. The liners may have an average surface dose rate of fifteen (15) rem per hour (or up to 380 rem/hr if a 10CFR50.59 evaluation has been completed).

The DAW facility will contain low-level radioactive waste that would result in dose rates less than the 10CFR20 requirements.

The dose rates resulting from these radwaste and spent fuel storage facilities will be monitored frequently as they are being utilized, and if necessary, a dose calculation model similar to that of Equation 5-1 will be developed and placed in the ODCM.

Administrative controls are implemented to ensure compliance to applicable regulations. The impact to the offsite dose will be evaluated on a case-by-case basis and added to the ODCM when applicable. A 10CFR50.59 analysis may be required for radwaste storage facilities.

5.4 Methodology

5.4.1 Deep Dose Equivalent

The deep dose equivalent, H_d , is comprised of four parts:

- Total body dose due to noble gas radionuclides in gaseous effluents (Section 4.2.2.3),
- Dose due to ^{16}N skyshine (Section 5.2),
- Total body dose due to radioactivity deposited on the ground (Section 4.2.3.1), and
- Other contained sources (Section 5.3), if applicable.

$$H_d = D_{tb} + D^{sky} + D^G + D^{OSF} \quad (5-2)$$

| where: | | (units) |
|-----------|--|---------|
| H_d | Deep Dose Equivalent (DDE) - Dose equivalent at the location of interest due to external total body exposure at a tissue depth of 1 cm. | [mrem] |
| D_{tb} | Total Body Dose, Effluents - DDE at the location of interest due to gamma radiation from noble gas radionuclides released in gaseous effluents. See Section 4.2.2.3. | [mrem] |
| D^{sky} | Dose Due to ^{16}N Skyshine - DDE due to ^{16}N skyshine for the period and location of interest. See Equation 5-1. | [mrem] |
| D^G | Dose From Ground Deposition - DDE due to ground deposition of non-noble gas radionuclides released in gaseous effluents. See Equation 4-15. | [mrem] |
| D^{OSF} | Dose From On-Site Storage Facilities - DDE at the location of interest due to gamma radiation from on-site storage facilities, if applicable. See Section 5.3. | [mrem] |

5.4.2 Committed Effective Dose Equivalent (CEDE)

The CEDE for internal exposures, $H_{E,50}$ is the sum of the products of the weighting factors applicable to each of the body organs, or tissues, that are irradiated and the committed dose equivalent (CDE) to those tissues.

$$H_{E,50} = \sum_T (W_T H_{T,50}) \quad (5-3)$$

| | | |
|----------------|--|---------|
| where: | | (units) |
| $H_{E,50}$ | Committed Effective Dose Equivalent - The committed effective dose equivalent due to internal exposures. | [mrem] |
| W_T | Weighting Factor - The weighting factor for organ or tissue (T), which is the proportion of stochastic effects resulting from the irradiation of that organ or tissue to the total risk of stochastic effects when the total body is irradiated uniformly. Values are given in Reference #93, Federal Guidance Report #11 and in 10CFR20. Dimensionless. | |
| $H_{T,50}$ | Committed Dose Equivalent - The total dose equivalent to organs or tissues (T) that will be received, after an intake of radioactive material by an individual, over the 50 year period following the intake, where: | [mrem] |
| | $H_{T,50} = D_{ja}^{NNG} + D_{ja}^{liq}$ | (5-4) |
| D_{ja}^{NNG} | Committed Dose Equivalent due to Non-Noble Gas Radionuclides - Sum of the dose to organ j of an individual of age group a due to non-noble gas radionuclides released in gaseous effluents during a specified time period. See Equation 4-14. | [mrem] |
| D_{ja}^{liq} | Total organ and total body dose commitment (CDE) due to Radioactivity in Liquid Effluents. Dose commitment to organ j and total body of age group a consuming water and fish containing radioactivity released in liquid effluents. See Equation 3-3. | [mrem] |

In order to be consistent with the dose factor data, upon which the current revision of 10CFR20 is based, the CDEs D^{NNG} and D^{liq} are now calculated using the dose factor data included in Federal Guidance Report #11 (Reference 93). Regulatory Guide 1.109 dose factors (Reference 6 and Section 4 of the ODCM) are still used for 10CFR50 Appendix I compliance.

5.4.3 Total Effective Dose Equivalent

The above relationships may then be combined into a single equation for the total effective dose equivalent (TEDE) as follows:

$$TEDE = H_d + H_{E,50} = D_{tb} + D^{sky} + D^G + \sum_T (W_T (D_{ja}^{NNG} + D_{ja}^{liq})) \quad (5-5)$$

| | | |
|--------|---|---------|
| where: | | (units) |
| TEDE | Total Effective Dose Equivalent - The sum of the deep dose equivalent (for external exposure) and the committed effective dose equivalent (for internal exposures). | [mrem] |

The remaining parameters are defined in Sections 5.4.1 and 5.4.3.

5.5 COMPLIANCE TO TOTAL DOSE LIMITS

5.5.1 Total Effective Dose Equivalent Limit - 10CFR20 Compliance

Dresden RECs limit the Total Effective Dose Equivalent (TEDE) to an annual limit of 100 mrem, as required by 10CFR20.1301 (a)(1). The regulations offer licensees the option of demonstrating compliance with one of two methods, 10CFR20.1301(b)(1) or 10CFR20.1301(b)(2). The RECs state that the 10CFR20.1301(b)(1) methodology has been selected to demonstrate compliance to 10CFR20.1301 (a)(1).

The general methodology for calculating the Total Effective Dose Equivalent is given in Section 5.4.3. In lieu of specific regulatory guidance, this evaluation is conservatively made for an adult living at the nearest residence.

In August of 1995, a revision to 10CFR20 was implemented that changed the definition of a member of the public. As a result, for each nuclear station, estimated doses were calculated for a member of the public who enters the site boundary, but is not authorized for unescorted access to the protected area of the site and does not enter any radiologically posted areas on the site. Realistic assumptions were made for occupancy times and locations visited while within the site boundary.

These evaluations indicate that the doses estimated for these members of the public are well within the 10CFR20 limits. These dose evaluations will be performed annually and if necessary, a model will be developed and included in the ODCM.

This evaluation dose is used to demonstrate compliance to 10CFR20 and satisfy station RECs and Technical Specifications (see ODCM Part I).

5.5.2 Total Dose due to the Uranium Fuel Cycle (40CFR190)

RECs and 40CFR190 limit the annual (calendar year) dose or dose commitment to any member of the public due to releases of radioactivity and to radiation from uranium fuel cycle sources to the following:

- Less than or equal to 25 mrem to the total body.
- Less than or equal to 25 mrem to any organ except the thyroid.
- Less than or equal to 75 mrem to the thyroid.

Total Dose Components

This requirement includes the total dose from operations at Dresden. This includes doses due to radioactive effluents (airborne and liquid) and dose due to direct radiation from non-effluent sources (e.g., sources contained in systems on site). It also includes dose due to plants under consideration, neighboring plants and dose due to other facilities in the uranium fuel cycle.

The operations comprising the uranium fuel cycle are specified in 40CFR190.02(b). The following are included to the extent that they directly support the production of electrical power for public use utilizing nuclear energy:

- Milling of uranium ore.
- Chemical conversion of uranium.
- Isotopic enrichment of uranium.
- Fabrication of uranium fuel.
- Generation of electricity by a light-watered-cooled nuclear power plant using uranium fuel.
- Reprocessing of spent uranium fuel.

Excluded are:

- Mining operations.
- Operations at waste disposal sites.
- Transportation of any radioactive material in support of these operations.
- The re-use of recovered non-uranium special nuclear and by-product materials from the cycle.

5.5.3 When Compliance Assessment is Required

Compliance with the 40CFR190 regulations is now required as part of demonstration of compliance to 10CFR20 regulations per 10CFR20.1301(d).

The dose due to the uranium fuel cycle is determined by equations 5-2 and 5-4, sections 5.4.1 and 5.4.2 respectively.

5.6 Summary of Compliance Methodology

The required compliance is given in Tables 1-1, 1-2, and 1-3. In Table 1-1, the dose components are itemized and referenced, and an indication of their regulatory application is noted. A more detailed compliance matrix is given in Table 1-3. The locations of dose receivers for each dose component are given in Table 1-2.

Further, Table 1-2 states the location of the receiver and occupancy factors, if applicable. In general, the receiver spends time in locations that result in maximum direct dose exposure and inhales and ingests radioactivity from sites that yield maximum pathway doses. Thus, the dose calculated is a very conservative one compared to the "average" receiver who does not go out of his way to maximize radioactivity uptakes. Finally, the connection between regulations, the ODCM equations, and the station RECs and Technical Specifications is given in Table 1-4.

Table 5-1
Parameters for Calculations of ¹⁶N Skyshine Radiation
from Dresden Units 2 and 3

| Location Number k | Activity | Occupancy Hours OH _k ^a | Occupancy Factor OF _k | Shielding Factor SF _k | Distance R _k (m) |
|----------------------|--------------------------------------|---|-------------------------------------|-------------------------------------|-----------------------------------|
| 1 | Living at home (nearest resident) | 8344 | 0.95 | 0.7 | 800 ^b |
| 2 | Fishing | 416 | 0.05 | 1.0 | 610 ^c |

$M_h = 5$
 $K = 3.60E-05 \text{ mrem}/(\text{MWe-hr})$

These parameters are used to obtain an initial estimate of skyshine dose to the maximally exposed member of the public using Equation 5-1. If desired, more realistic parameters could be used in place of these to refine the estimate. For example, one could determine whether the nearest resident really fishes the specified number of hours at the specified location.

- ^a The amount of time in a year that a maximally exposed fisherman would spend fishing near the site is estimated as 12 hours per week for 8 months per year. This yields an estimate of:

$$[12 \text{ hours/week}] \times [(8 \text{ months/yr})/(12 \text{ months/yr})] \times [52 \text{ weeks/yr}] = 416 \text{ hours/yr}$$

The remaining time is assumed to be spent at the nearest residence.

- ^b Distance to nearest residence (See ODCM Table 4-1).
- ^c Estimated from a drawing of the site.
- ^d The OF_k is the quotient of the number of hours a location is occupied and the number of hours in a year. Thus $OH_k/8760 \text{ hours} = OF_k$ rounded to the 0.01 digit.

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6.0 RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM LOCATIONS

- 6.1 The Radiological Environmental Monitoring Program monitoring locations for the environs around Dresden Station are given in Table 6-1. Figure 6-1 and Figure 6-2 show general sampling and monitoring locations. See RECs Table 12.6-1 for sampling and analysis requirements.
 - 6.1.1 Distances provided for sampling/monitor locations are approximate.
 - 6.1.2 Sample locations for food products (vegetation) may vary based on availability and therefore are not identified in the table or figures. This does not affect the sampling or analysis requirements of the RECs.
 - 6.1.3 The fish monitoring locations are not identified exactly on the map. The points, D-28 and D-46, represent the general area where the samples are taken.
 - 6.1.4 Airborne sampling stations D-01, D-02, and D-03 are not REMP samples, but are special samples required per Section 11.5.1.10 of the UFSAR. They may be discontinued pending revision of the aforementioned section.
 - 6.1.5 Individual areas where Illinois River dredge spoils are deposited do not require sampling if no additions were made to that area since last sample collection.

Table 6-1 (Page 1 of 4)
Radiological Environmental Monitoring Program Locations

| Exposure Pathway and/or Sample | Direction / Sector | | Designator | Distance | | Designator | Distance | |
|-----------------------------------|--------------------|---|---|----------|--------|----------------------------|----------|--------|
| 1. Direct Radiation | | | a. Indicators - Inner Ring | | | b. Indicators - Outer Ring | | |
| | N | A | D-101-1 | 1.0 mi | 1.6 km | D-201-1 | 4.8 mi | 7.7 km |
| | N | A | D-101-2 | 1.0 mi | 1.6 km | D-201-2 | 4.8 mi | 7.7 km |
| | NNE | B | D-102-1 | 1.4 mi | 2.2 km | D-202-1 | 5.1 mi | 8.2 km |
| | NNE | B | D-102-2 | 1.3 mi | 2.2 km | D-202-2 | 5.1 mi | 8.2 km |
| | NE | C | D-103-1 | 1.2 mi | 1.9 km | D-203-1 | 4.7 mi | 7.6 km |
| | NE | C | D-103-2 | 1.2 mi | 1.9 km | D-203-2 | 4.8 mi | 7.7 km |
| | ENE | D | D-104-1 | 1.7 mi | 2.7 km | D-204-1 | 5.1 mi | 8.1 km |
| | ENE | D | D-104-2 | 1.7 mi | 2.7 km | D-204-2 | 5.0 mi | 8.1 km |
| | E | E | D-105-1 | 1.5 mi | 2.4 km | D-205-1 | 4.0 mi | 6.5 km |
| | E | E | D-105-2 | 1.5 mi | 2.4 km | D-205-2 | 4.0 mi | 6.5 km |
| | ESE | F | D-106-1 | 1.1 mi | 1.8 km | D-206-1 | 3.5 mi | 5.6 km |
| | ESE | F | D-106-2 | 1.1 mi | 1.8 km | D-206-2 | 3.5 mi | 5.6 km |
| | SE | G | D-107-1 | 1.4 mi | 2.3 km | D-207-1 | 4.2 mi | 6.8 km |
| | SE | G | D-107-2 | 1.4 mi | 2.3 km | D-207-2 | 4.3 mi | 6.9 km |
| | SSE | H | D-108-1 | 1.9 mi | 3.0 km | D-208-1 | 4.9 mi | 7.8 km |
| | SSE | H | D-108-2 | 1.9 mi | 3.0 km | D-208-2 | 4.9 mi | 7.8 km |
| | S | J | D-109-1 | 0.8 mi | 1.3 km | D-209-1 | 4.1 mi | 6.6 km |
| | S | J | D-109-2 | 0.8 mi | 1.3 km | D-209-2 | 4.2 mi | 6.7 km |
| | SSW | K | D-110-3 | 0.9 mi | 1.4 km | D-210-1 | 4.9 mi | 7.9 km |
| | SSW | K | D-110-4 | 0.9 mi | 1.4 km | D-210-2 | 4.9 mi | 8.0 km |
| | SW | L | D-111-1 | 0.6 mi | 1.0 km | D-211-1 | 4.8 mi | 7.7 km |
| | SW | L | D-111-2 | 0.6 mi | 1.0 km | D-211-2 | 4.8 mi | 7.7 km |
| | WSW | M | D-112a-1 | 0.7 mi | 1.1 km | D-212-3 | 6.0 mi | 9.6 km |
| | WSW | M | D-112a-2 | 0.7 mi | 1.1 km | D-212-4 | 5.9 mi | 9.6 km |
| | W | N | D-113-1 | 0.9 mi | 1.4 km | D-213-1 | 4.6 mi | 7.4 km |
| | W | N | D-113-2 | 0.9 mi | 1.4 km | D-213-2 | 4.5 mi | 7.3 km |
| | WNW | P | D-114-1 | 0.9 mi | 1.5 km | D-214-1 | 5.0 mi | 8.0 km |
| | WNW | P | D-114-2 | 0.9 mi | 1.5 km | D-214-2 | 5.0 mi | 8.0 km |
| | NW | Q | D-115-1 | 0.8 mi | 1.3 km | D-215-1 | 4.8 mi | 7.8 km |
| | NW | Q | D-115-2 | 0.8 mi | 1.3 km | D-215-2 | 4.8 mi | 7.8 km |
| | NNW | R | D-116-1 | 1.0 mi | 1.6 km | D-216-1 | 4.9 mi | 7.8 km |
| | NNW | R | D-116-2 | 1.0 mi | 1.6 km | D-216-2 | 4.9 mi | 7.8 km |
| c. | | | <u>Other Indicators</u> - One at each of the airborne location given in part 2.a and 2.b. | | | | | |
| d. | | | <u>Control</u> - One at each airborne control location given in part 2.c. | | | | | |

Table 6-1 (Page 3 of 4)
Radiological Environmental Monitoring Program Locations

| Exposure Pathway and/or Sample | Designator, Description | Direction / Sector | Distance |
|---|---|--|---|
| <p>3. <u>Waterborne</u></p> <p>a. <u>Surface Water</u></p> <p>b. <u>Ground/Well</u></p> <p>c. <u>Drinking Water</u></p> <p>d. <u>Sediment from Shoreline</u></p> <p>e. <u>Dredging Spoils</u></p> | <p>a. <u>Indicator</u></p> <p>D-21, Illinois River at EJ&E bridge</p> <p>b. <u>Control</u></p> <p>D-52, DesPlaines River at Will Road D-57, Kankakee River at Will Road</p> <p>a. <u>Indicators</u></p> <p>D-23, Thorsen Well, 6310 Dresden Road D-35, Dresden Lock & Dam</p> <p>Currently there are no community drinking water supplies that could be affected by the station discharge within 10 km (6.2 mi) of the station discharge.</p> <p>a. <u>Indicator</u></p> <p>D-27, Illinois River at Dresden Lock & Dam</p> <p>a. <u>Indicator</u></p> <p>One sample from each major dredging of Illinois River within 1 mile downstream of station discharge point.</p> | <p>WNW P</p> <p>ESE F SE G</p> <p>S J NW Q</p> <p>NW Q</p> | <p>1.4 mi 2.3 km</p> <p>1.1 mi 1.8 km 2.0 mi 3.2 km</p> <p>0.7 mi 1.1 km 0.8 mi 1.3 km</p> <p>0.8 mi 1.3 km</p> |

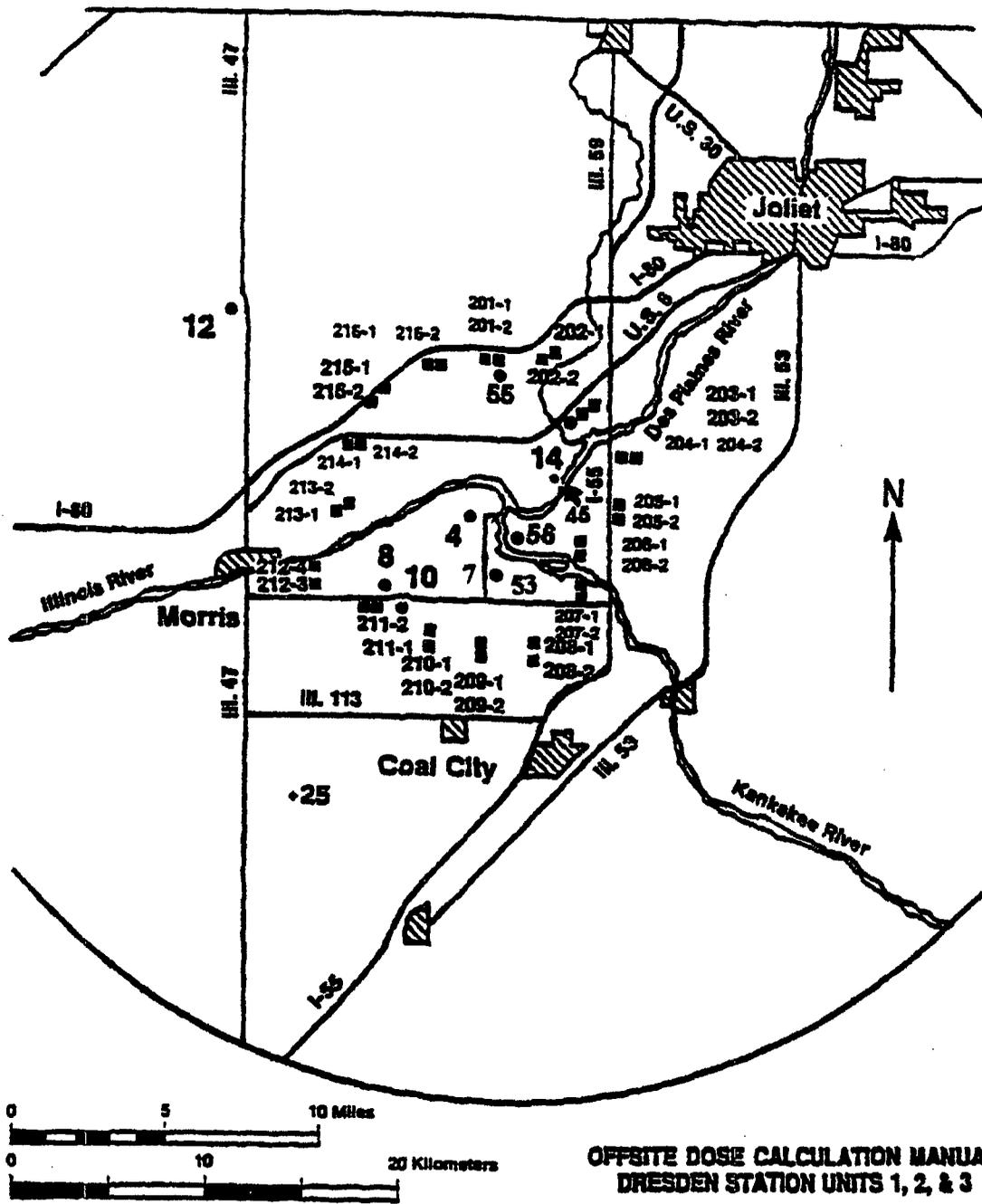
Table 6-1 (Page 4 of 4)
Radiological Environmental Monitoring Program Locations

| Exposure Pathway and/or Sample | Designator, Description | Direction / Sector | Distance |
|---|---|---|---|
| <p>4. <u>Ingestion</u></p> <p>a. <u>Milk</u></p> <p>b. <u>Fish</u></p> <p>c. <u>Food Products</u></p> | <p>a. <u>Indicator</u></p> <p>There are no dairies within 6.2 miles of the station.</p> <p>b. <u>Control</u></p> <p>D-25, Vince Biros Farm, Reed Road</p> <p>a. <u>Indicator</u></p> <p>D-28, Dresden Pool of Illinois River</p> <p>b. <u>Control</u></p> <p>D-46, DesPlaines River upstream of discharge</p> <p>a. <u>Indicators</u></p> <p>Two samples from each of the four major quadrants within 6.2 miles (10 km) of the station.</p> <p>b. <u>Control</u></p> <p>Two samples from a location between 9.3 to 18.6 miles (15 to 30 km) from the station.</p> | <p>SW L</p> <p>NNW R</p> <p>ESE F</p> | <p>11.3 mi 18.2 km</p> <p>0.9 mi 1.4 km</p> <p>1.2 mi 1.9 km</p> |

Table 6-2

Sector Code Definitions

| <u>Sector Code</u> | <u>Sector Direction</u> | <u>Angle from North (degrees)</u> |
|--------------------|-------------------------|-----------------------------------|
| A | N | $348.75 < \theta \leq 11.25$ |
| B | NNE | $11.25 < \theta \leq 33.75$ |
| C | NE | $33.75 < \theta \leq 56.25$ |
| D | ENE | $56.25 < \theta \leq 78.75$ |
| E | E | $78.75 < \theta \leq 101.25$ |
| F | ESE | $101.25 < \theta \leq 123.75$ |
| G | SE | $123.75 < \theta \leq 146.25$ |
| H | SSE | $146.25 < \theta \leq 168.75$ |
| J | S | $168.75 < \theta \leq 191.25$ |
| K | SSW | $191.25 < \theta \leq 213.75$ |
| L | SW | $213.75 < \theta \leq 236.25$ |
| M | WSW | $236.25 < \theta \leq 258.75$ |
| N | W | $258.75 < \theta \leq 281.25$ |
| P | WNW | $281.25 < \theta \leq 303.75$ |
| Q | NW | $303.75 < \theta \leq 326.25$ |
| R | NNW | $326.25 < \theta \leq 348.75$ |



- Air Sampling Location
- ◆ Milk Location
- TLD Location

FIXED AIR SAMPLING AND TLD SITES, OUTER RING TLD LOCATIONS, AND MILK LOCATION

Figure 6-1

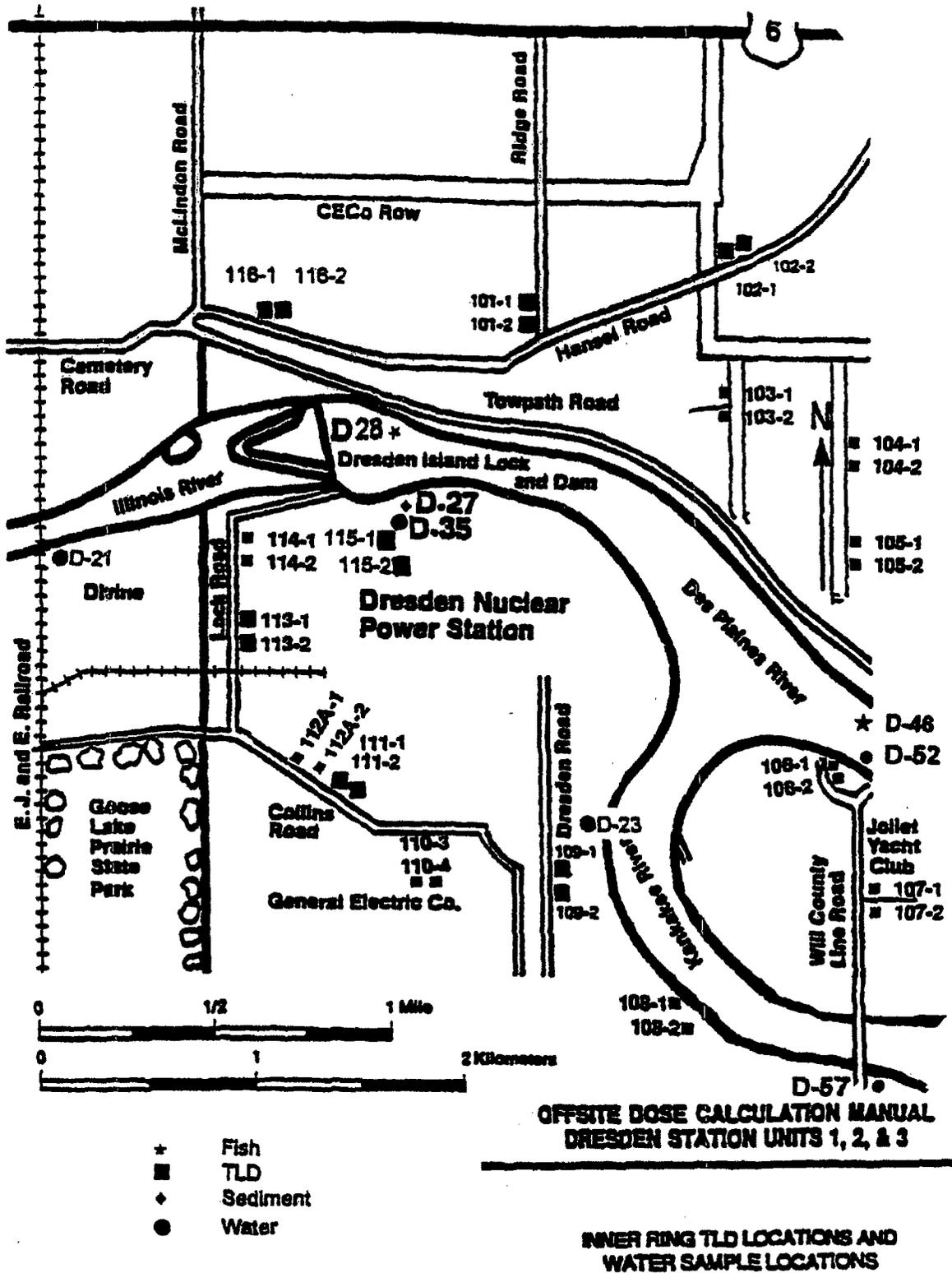


Figure 6-2

**DNPS Offsite Dose Calculation Manual
Changes Made in 2009**

DNPS Offsite Dose Calculation Manual Changes Made in 2009

Revision 8 of the ODCM was issued on May 29, 2009 and made the following changes:

- Implemented Technical Specification amendments 43 (Unit 1), 230 (Unit 2), and 223 (Unit 3) that clarifies dose projection requirements.
- Implemented Technical Specification amendments 163 (Unit 2) and 158 (Unit 3) that changes the offgas radiation monitor high alarm setpoints to 1.5 times normal full-power value.
- Changed OPERABILITY / OPERABLE to FUNCTIONALITY / FUNCTIONAL to meet the intent of NRC Regulatory Issue Summary (RIS) 2005-20, revision 1, to apply OPERABILITY / OPERABLE only to safety-related structures, systems, or components.
- Reduced the maximum allowable Liquid Radwaste Effluent Monitor alarm setpoint to ensure the high activity alarm is below the high fail setpoint.
- Clarified Land Use Census requirements to require enumeration and feed sources of milk animals instead of livestock.

The changes are listed in the following table:

| Page | Description of Change |
|--|---|
| i, iv, vi II-1.1 | Removed (RECs) when it followed Radioactive Effluent Controls to correct acronym use. (RECs are <i>Radiological</i> Effluent Controls, terminology used to match regulatory guidance. <i>Radioactive</i> Effluent Controls is a part of the ODCM required by the Technical Specifications that contains the RECs.) Updated page numbers affected by other changes. These are editorial enhancements. |
| Throughout document | Changed <i>OPERABLE</i> and its derivatives to <i>FUNCTIONAL</i> and its derivatives (e.g., <i>OPERABILITY</i> is changed to <i>FUNCTIONALITY</i> , <i>inoperable</i> is changed to <i>non-functional</i> , etc.). Added the definition of <i>FUNCTIONAL</i> / <i>FUNCTIONALITY</i> from OP-AA-108-105 and NRC Inspection Manual Part 9900, section 3.5 to the definitions and removed the definition of <i>OPERABLE</i> / <i>OPERABILITY</i> . This change is made to limit the use of <i>OPERABLE</i> to safety-related equipment only. |
| I-1.1-2 | Added document number to ODCM definition. This is an editorial enhancement. |
| I-1.3-1 | Changed <i>Radioactive</i> to <i>Radiological</i> to match proper usage. Added reference to the Unit 1 Technical Specifications. These are editorial enhancements. |
| I-12.3-7 I-12.3-8 I-12.4-5 (&6) I-12.4-6 (7,8) I-12.4-7 (9) I-12.4-8 (10) | Removed <i>and projected</i> from RSR 12.3.2.1, RSR 12.4.2.1, and RSR 12.4.3.1. Added new RSR 12.3.2.2, RSR 12.4.2.2, and RSR 12.4.3.2 to " <i>Determine projected dose contributions from [(liquid effluents), (noble gases), or (iodine-131, iodine-133, tritium, and radionuclides in particulate form with half-lives > 8 days), as applicable to the specific REC] in accordance with the methodology in the ODCM.</i> " Re-numbered old RSR 12.3.2.2 to 12.3.2.3, and updated references to the applicable RSRs. This implements Tech Spec Amendments 43 (Unit 1), 230 (Unit 2), and 223 (Unit 3). |
| I-12.6-15 | Changed Land Use Census requirements to require enumeration and feed sources of milk animals and not livestock. The grass-cow-milk pathway for iodine ingestion is more significant than the grass-cow-meat pathway, therefore the number and feeding habits of milk animals is more important to the station. |
| I-B12.5-1(2) | Changed Effluents Program to Radioactive Effluent Controls to clarify the program used to implement requirements. This is an editorial enhancement. |
| II-2.2 | Changed maximum Liquid Radwaste Effluent Monitor setpoint from " <i>500,000 counts</i> " to " <i>450,000 counts per minute</i> ." This is changed to ensure the high activity alarm is set below the high fail setpoint, corrects the units, and is a conservative change. |

| Page | Description of Change |
|--------------------------------------|--|
| II.2-8 | Changed Condenser Air Ejector Monitors setpoints from " <i>The high-high trip setpoint is established at $\leq 100 \mu\text{Ci/sec}$ per MWt ($\approx 2.5E5 \mu\text{Ci/sec}$) and the high alarm is established at $\leq 50 \mu\text{Ci/sec}$ per MWt ($\approx 1.25E5 \mu\text{Ci/sec}$).</i> " to " <i>The high-high trip limit is established at $\leq 100 \mu\text{Ci/sec}$ per MWt (252,700 $\mu\text{Ci/sec}$). The high alarm is set at 1.5 times the normal full power background with hydrogen addition to satisfy licensing commitments associated with the main steam line monitor Technical Specification amendments.</i> " This implements a licensing commitment (Tech Spec amendments 163 (Unit 2) and 158 (Unit 3)) and changes the high-high setpoint from an approximate value to the Tech Spec value (252,700). |
| II.3-3 II.4-5 II.4-7 II.4-9 | Removed " <i>for the current calendar quarter and the current calendar year</i> " from the descriptions of effluent dose calculation requirements. This is not a change to the requirements, and is an editorial enhancement. |

Revision 9 of the ODCM was issued on August 18, 2009. The revision removes the Unit 1 Chimney System Particulate, Iodine, and Noble Gas (SPING) monitor and associated in-line monitoring requirements and removes Unit 1 Chimney noble gas and tritium sampling requirements. All fuel is removed from Unit 1 and the Unit 1 Spent Fuel Pool is drained, which removed the source of these nuclides from Unit 1. Particulate and iodine sampling requirements were changed to be required only during operation of the Unit 1 Gaseous Monitoring System (the only potential source of effluent flow via the Unit 1 Chimney). The changes are listed in the following table:

| Page | Description of Change |
|----------------------|---|
| I-1.1-5 | Added Unit 1 Technical Specification references. This is an editorial enhancement. |
| I-12.2-11 | 2.a <i>Unit 1 Chimney Monitoring SPING</i> was changed to <i>Unit 1 Chimney Monitoring</i> . 2.a.1) <i>Noble Gas Monitor</i> was removed and remaining items renumbered. <i>Iodine Sampler and Particulate Sampler</i> applicable modes or other specified condition was changed from <i>At all times</i> (footnote a) to <i>During operation of the Unit 1 Gaseous Monitoring System</i> (new footnote f). |
| I-12.4-2 I-12.4-4 | Deleted <i>1 Chimney</i> from Gaseous Release Type A (Noble Gas) and Gaseous Release Type B (Tritium). Added reference to footnote 9 to 1 Chimney under Gaseous Release Type C (particulate and iodine). Added footnote 9 that states <i>Sampling of the Unit 1 Chimney is not required if the Unit 1 Gaseous Monitoring System is not discharging via the Unit 1 Chimney</i> . |
| II-2.6 | Section title <i>Unit 1 Chimney Monitor</i> was changed to <i>Unit 1 Chimney Sampler</i> . The section was revised to read: <i>Effluent from the chimney is sampled via an isokinetic probe. The sampler provides for continuous particulate and iodine sampling of the Unit 1 Chimney effluent. This sampler performs no automatic isolation or control functions.</i> |
| II.2-8 | Corrected typographical error in Equation 2-4. Corrected equation and section references in the paragraph at the bottom of the page. These are editorial enhancements. |
| II.2-12 | Removed noble gas monitors from the chimney drawing. |
| II.4-3 | Corrected definition of terms used in Equation 4-2. This is an editorial enhancement. |